Strategies to relieve intraluminal obstructions in inaccessible segments of the ascending, transverse, and descending colon

Julie Dechant[1]

[1]University of California, School of Veterinary Medicine

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Abstract

Enteroliths, faecaliths, ingested foreign bodies, and bezoars are examples of focal intraluminal obstructions that can lodge in inaccessible parts of the gastrointestinal tract. Pneumatic lithotripsy, as described in the accompanying article, is an option to manage obstructions caused by mineralized concretions. However, pneumatic lithotripsy may not be safe or effective for all intraluminal obstructions. Awareness of other strategies or secondary abdominal approaches to address these challenging presentations can help improve the surgeon's ability to problem solve in these situations and achieve successful resolution of the obstruction.

Introduction

Enteroliths, faecaliths, ingested foreign bodies, and bezoars are examples of focal intraluminal obstructions that can lodge in inaccessible parts of the gastrointestinal tract (Hanson and Schumacher 2021; Hassel 2002; Klohnen 2013; Oreff et al 2020; Pierce, 2010). Gastrointestinal segments that are particularly difficult to surgically access and manage include stomach, duodenum, distal ileum, base and dorsal body of cecum, aboral right dorsal colon, transverse colon, and the most oral and aboral limits of the descending (small) colon (Marshall and Blikslager 2019). The accompanying article by Machado Amaral Rosa *et al* (2023) describes the use of pneumatic lithotripsy to aid in resolution of enterolith obstructions in the oral and aboral descending colon and to prevent need for a second enterotomy in removal of an enterolith from the left dorsal colon.

Application of Lithotripsy

Lithotripsy has been used to fragment uroliths in the horse (Katzman*et al* 2016; De Bernadris *et al* 2019; Nolazco Sassot*et al* 2020), as well as other mineralized concretions in horses. This article describes application of the pneumatic lithotripsy to enteroliths. The efficacy and efficiency of lithotripsy in fragmenting mineralized concretions appears to be dependent on the size of the concretion and on its composition. Uroliths as large as 10-12 cm have been fragmented within the bladder of female horses (Nolazco Sassot*et al* 2020), whereas <10 cm urolith size have been described for male horses (De Bernadris *et al* 2019; Katzman*et al* 2016). This size difference is attributed to the ease of removing urolith fragments from the bladder in the relatively large and expansile mare urethra compared to the narrower and more limited access via a perineal urethrotomy in male horses.

The composition and surface characteristics of the mineralized concretion is also important when considering the efficiency of lithotripsy. The article by Machado Amaral Rosa *et al* (2023) noted that smooth surfaced enteroliths were more difficult to fragment than irregularly surfaced enteroliths, as were enteroliths with rigid cores and less porosity. Similarly, type 1 calcium carbonate uroliths in horses have been described as easier to fragment than the harder and smoother type 2 calcium carbonate uroliths (De Bernadris *et al*2019). Although ingesta and foreign bodies, such as hay nets, twine, plastic, or rope, can serve as a nidus for mineralized concretions, most enteroliths have small, solid niduses, such as metal fragments, rocks, or grains of sand (Hassel 2002; Pierce 2009). Clinical experience, supported by available geochemical analysis of typical equine enteroliths, would suggest that the majority of enteroliths are not hollow-centered formations (Hassel *et al* 2001; Rouff *et al*2018; Dechant, personal observation).

Machado Amaral Rosa *et al* (2023) stated that advantages of their pneumatic lithotripsy technique for management of enteroliths include ability to use smaller enterotomies through sites that are remote to the site of obstruction and reduced surgical time. Comparisons for surgery time were made to an isolated case report describing a particularly difficult presentation of obstructive enterolithiasis (Barrett and Munstermann 2013). In another report of surgical management of enterolithiasis, mean surgery time was 128 +/- 31 minutes (range 70-200 minutes) with 13% requiring 1 enterotomy, 83% of surgeries requiring 2 enterotomies, and 4% requiring 3 enterotomies (Torrent Crosa *et al* 2020). In this case series, mean surgery time was 135 minutes (range 120-145 minutes) with 4 cases requiring 1 enterotomy and 1 case requiring 2 enterotomies (Machado Amaral Rosa *et al* 2023). This suggests that while the time advantage of pneumatic lithotripsy for enterolithiasis proposed by Machado Amaral Rosa *et al* (2023) may not be as profound as described.

In a studies evaluating survival following surgical management of ascending colon or descending colon enterolithiasis, short-term survival was 95-96% with no difference in incidence of complications between enterotomies of the pelvic flexure or descending colon (Pierce *et al* 2010; Hassel *et al* 1999). Pneumatic lithotripsy as described in this case series does require an enterotomy to introduce the instrument. Although the enterotomy may be smaller than those needed to directly remove an enterolith, the proximity of the enterotomy and the non-sterile lithotripter to the abdominal incision and the time needed to fragment the enterolith which prolongs the time the intestinal lumen is open should be balanced against the benefits of a smaller enterotomy.

Pierce et al (2010) documented that 87% of horses with descending colon enterolithiasis had some degree of mural damage. Although Machado Amaral Rosa *et al* (2023) did not experience full thickness intestinal perforation with their technique, one case did develop partial thickness penetration of the intestinal wall despite the lithotripsy procedure being directed at an enterolith that was well exteriorized from the abdomen and readily accessible in a location 30 cm from the pelvic flexure. In lithotripsy disruption of ureteroliths in people, ureteral perforation or extra-ureteral migration of ureteral calculi occurred in approximately 0.85% of cases, with surgeon inexperience and longer operative times being associated with increased complication rates (Georgescu *et al* 2014). An *ex vivo* study comparing lithotripsy damage on urinary tract tissue found that tissue damage and risk of perforation was affected by the type of lithotripter, tissue type, probe force and duration of contact between probe and tissue (Sarkissian *et al* 2015). While it is not known how this information extrapolates to equine intestine, equine surgeon experience is likely to be limited with this technique and it is important to be as careful when using pneumatic lithotripsy as the authors of this case series emphasize (Machado Amaral Rosa *et al* 2023).

Pneumatic lithotripsy as described in this case series (Machado Amaral Rosa *et al* 2023) is a useful tool for the surgeon to have in their toolbox when presented with obstructive enterolithiasis. Pneumatic lithotripsy is limited to mineralized concretions, and other types of intraluminal obstructions can occur, such a foreign body or faecalith obstructions. It is important for the surgeon to be knowledgeable about other techniques for mobilizing intraluminal obstructions because other techniques may be more appropriate or preferred by the surgeon.

Right Dorsal Colon or Descending Colon Enterotomy Technique

For all of these procedures, at least one enterotomy will be necessary. Whenever an antimesenteric taenia is present, the enterotomy incision should be located within the center of the taenia (right dorsal colon or descending colon) (Archer *et al* 1988; Beard *et al* 1989). Unless the enterotomy will be in a segment that can be exteriorized away from the abdomen, such as the pelvic flexure, the affected segment of intestine should be isolated from the rest of the abdomen with moistened laparotomy sponges and sterile plastic barrier drapes. If the targeted intestine is being elevated under tension, the segment can be supported and elevated by a sterile hand within the abdomen. Stay sutures (or Babcock forceps) should be used within the taenia prior to the enterotomy incision to stabilize and elevate the site to reduce contamination. Suction should be used throughout the procedure to aspirate blood and ingesta to minimize leakage of intestinal contents and contamination of the surgical field. Closure of the enterotomy should be done in two layers using 2-0 absorbable suture: a full thickness apposition continuous pattern for the first layer and oversewn by an inverting seromuscular continuous pattern (Hassel 2002). While the inclusion of mucosa within descending colon enterotomies has not been determined to be essential (Beard *et al* 1989), it does appear to be advantageous to compress submucosal vessels for the large colon (Doyle *et al* 2003). Since intramural or submucosal hematomas can occur spontaneously in the descending colon (Hanson and Schumacher 2021; Schumacher and Mair 2002), full thickness closure of descending colon enterotomies appears prudent as well. While lumen diameter is not limiting for closure of right dorsal colon enterotomies, it is important to be precise with conservative suture bite sizes and minimal inversion when closing descending colon enterotomies. The enterotomy site should be carefully lavaged and cleaned of any contamination before the intestinal segment is returned to the abdomen.

Resolution of Intraluminal Obstructions through Ventral Midline Celiotomy

For intraluminal obstructions that are known preoperatively to be located in the right dorsal colon, transverse colon, and oral descending colon, the celiotomy incision should be positioned relatively more cranial on ventral midline, starting at least 5-10 cm cranial to the umbilicus (Hassel 2002). If the location of the obstruction is not known preoperatively (fecalith, foreign body, false negative radiographs for enteroliths), extending the incision more cranially may aid exteriorization of these intestinal segments.

The basic strategy for mobilizing right dorsal colon and oral to mid transverse colon obstructions is hydropulsion. This entails using intraluminal lavage through a pelvic flexure enterotomy to evacuate all ingesta oral to the obstruction (right dorsal colon, including ampulla coli, and oral transverse colon, as applicable). Once the colon is emptied of ingesta, water distension of the colon combined with gentle ballottement of the obstruction can free it from the mucosa and allow it to move orally into the ampulla coli where it then can be manipulated within the dorsal colon and exteriorized from the abdomen (Hanson and Schumacher 2021; Hassel 2002; Oreff *et al* 2020; Pierce 2009). This author has observed on some occasions that the transverse colon appears to spasm orally to obstructions in the transverse colon, and this spasming does not consistently relax with fluid distension. One strategy that may ease intestinal spasming is topical application of 2% lidocaine (Hassel and Yarbrough 1998). Conservative doses (˜0.1 mg/kg IV) of butylscopolammonium bromide appears to be helpful in relaxing these intestinal spasms, allowing oral movement of the obstruction, and resolving the obstruction, although the author is mindful of the cardiovascular effects of this drug in the anesthetized horse (Loomes 2020). Typically, intraluminal obstructions within the right dorsal colon or transverse colon are too large to be removed via the pelvic flexure enterotomy, so a second enterotomy must be performed or if appropriate, a lithotripsy technique used such as described by Machado Amaral Rosa *et al* (2023).

For obstructions that are not resolved by hydropulsion, particularly obstructions in the mid to distal transverse colon and very oral descending colon or the very aboral descending colon, retropulsion or retrograde flushing may be a useful technique (Hanson and Schumacher 2021; Klohnen 2013; Pierce 2009; Pierce *et al* 2010; Oreff*et al* 2020; Schumacher and Mair 2002; Taylor *et al* 1979). Retropulsion was used in 13% of descending colon enterolith obstructions in one case series (Pierce *et al* 2010). Retropulsion is the use of water distension and hydropressure of the intestine aboral to the obstruction via a high enema. The success of this technique requires the emptying of ingesta from oral to the obstruction and relaxation of the oral segment to allow movement of the obstruction. Retropulsion should only be used for obstructions that cannot be accessed otherwise, because the intestine adjacent and oral to an obstruction is often compromised by some degree of mural damage and may be prone to rupture (Pierce *et al* 2010).

To facilitate elevation of oral segments of the descending colon to the level of the abdominal incision, the use of nondepolarizing neuromuscular blocking agents, such as atracurium, pancuronium, etc., by the anaesthetist may allow relaxation of the body wall so that the abdominal incision can be manually pushed downward to allow exteriorization of most oral descending colon (Hassel 2002). Another suggested technique is to temporarily remove the horse from positive pressure ventilation to decrease the abdominal movements with each breathe and facilitate exteriorization of the very oral descending colon (Klohnen 2013). It is important to emphasize that neuromuscular blocking agents and removal of positive pressure ventilation cannot be performed together because neuromuscular blocking agents also paralyze the respiratory muscles and positive pressure ventilation is an essential requirement during neuromuscular blockade. The applicability of either of these techniques will depend on the experience, comfort, and pharmaceutical repertoire of the anaesthesia staff.

Another technique to facilitate aboral movement of an intraluminal obstruction within the descending colon is partial thickness taeniotomy (Hassel 2002; Hassel and Yarbrough 1998; Klohnen 2013; Pierce 2009; Schumacher and Mair 2002). This technique can be used to advance an obstruction a few centimeters (4-15 cm) aborally to allow the enterotomy to be made in a more exteriorized segment of descending colon or in a segment of descending colon that has not been compromised by the pressure of the obstruction (Hassel and Yarbrough 1998). A partial thickness taeniotomy is performed by creating a seromuscular incision in the middle of the antimesenteric taenia approximately 8-15 cm aboral to the obstruction (Hassel 2002; Hassel and Yarbrough 1998). The partial thickness seromuscular incision is extended orally to the level of the obstruction using Metzenbaum scissors or a scalpel blade. This incision allows maximum stretching of the mucosa within the taeniotomy, effectively increasing the intraluminal diameter. Gentle pressure is applied to the obstruction to advance it aborally, being careful to monitor when the stretched mucosa begins to rupture or the desired location for the enterotomy is achieved (Hassel 2002; Hassel and Yarbrough 1998). At that time, manipulations should be stopped and the enterotomy is extended through the mucosa in a controlled manner to allow removal of the enterolith. Closure of the enterotomy is routine, as described earlier.

Secondary Abdominal Approaches

Alternative surgical approaches to access the most oral limits of the descending colon include left paramedian (De Oliveira *et al* 2009) or left flank laparotomy (Turek *et al* 2019). In both instances, an initial ventral midline celiotomy was used for exploration, diagnosis and localization of the obstruction, and determination that it was not accessible through a ventral midline approach. In the De Oliveira*et al* (2009) report, sufficient exposure of the affected descending colon for enterotomy through the secondary paramedian approach was facilitated by elevating the obstructed segment of the oral descending colon by a surgeon with their arm through the ventral midline incision. The details of the location and surgical technique left flank laparotomy approach in Turek *et al* (2019) were not sufficiently described to determine if it was a paramedian approach while the horse was in dorsal recumbency or if the horse was repositioned into right lateral recumbency (after closing the original celiotomy incision). Other reports describing flank laparotomy for descending colon lesions were based on financial or patient constraints and flank laparotomy was not performed to improve access to the oral or aboral limits of the descending colon (Herbert *et al* 2021). A right flank laparotomy was used to access an obstruction within the descending duodenum when a ventral midline approach was not successful (Durham 1998).

For very aboral descending colon obstructions, either a paramedian approach or a parainguinal approach (Barrett and Munstermann 2013; Turek*et al* 2019) can be used to improve access for exteriorization. Similar to the secondary paramedian approach described by De Oliveira*et al* (2009), elevation of the descending colon to a parainguinal or parainguinal incision can be facilitated by a surgeon with their arm through the ventral midline incision. Barrett and Munstermann (2013) utilized a right parainguinal approach for their surgery; however, they comment that a left parainguinal approach may be more advantageous based on the descending colon anatomy (Barrett and Munstermann 2013; Klohnen 2013). The sidedness for the parainguinal incision could be determined in surgery via a ventral midline celiotomy or through manipulation of a palpable obstruction via rectal palpation based on which side allows easier elevation, as well as the preferences of the surgeon (which depends on their handedness and where they stand relative to the horse (caudal or craniolateral)).

Conclusions

Many intraluminal obstructions of the ascending, transverse, and descending colons can be manipulated, exteriorized, accessed, and removed through routine enterotomy approaches. The case series by Machado Amaral Rosa *et al* (2023) highlights the successful use of pneumatic lithotripsy to facilitate resolution of obstructive enterolithiasis through small enterotomies remote to the site of obstruction. This provides the surgeon with another tool to consider when challenged by similar types of obstructions. It is important to recognize that pneumatic lithotripsy may not be safe or effective for all intraluminal obstructions. Awareness of other strategies or secondary abdominal approaches to address these challenging presentations can help improve the surgeon's ability to problem solve in these situations and achieve successful resolution of the obstruction.

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