Comparison of Biofragmentable Anastomosis Ring and Sutured Anastomoses for Subtotal Colectomy in Cats with Idiopathic Megacolon

STEWART RYAN, BVSc (Hons), MACVSc, HOWARD SEIM III, DVM Diplomate ACVS, CATRIONA MACPHAIL, DVM, Diplomate ACVS, RON BRIGHT, DVM, MS, Diplomate ACVS, and ERIC MONNET, DVM, PhD, Diplomate ACVS & ECVS

Objective—To report use of a biofragmentable anastomosis ring (BAR) device in cats with idiopathic megacolon (FIM) and compare outcome after subtotal colectomy with sutured colocolic anastomosis.

Study Design—Retrospective study.

Animals—Nineteen cats with megacolon.

Methods—Medical records (January 1990–January 2004) of cats treated surgically for idiopathic megacolon with sutured (SUT) or BAR anastomosis were retrieved and reviewed. Operative, short- and long-term complications, and survival times were recorded and Kaplan–Meier survival analysis used to assess outcome.

Results—There were 11 SUT and 8 BAR cats. One BAR cat had anastomotic dehiscence 36 hours after surgery. Mild serosal tearing during BAR insertion in 6 cats was corrected by suture reinforcement. One SUT cat developed anastomotic stricture at 32 days. Short-term complication rates at 3 and 7 days were 18% and 45% in the SUT group and 25% and 87.5% in the BAR group, respectively (P = .058). Two SUT cats had persistent loose stool consistency and were euthanatized 254 and 1661 days after surgery. One BAR cat had recurrence of constipation which was managed medically. Long-term complication rates were not significantly different between SUT and BAR (P = .61). The 1 and 4-year survival rates were 90% for SUT and 100% for BAR (P = .29).

Conclusions—No difference was detected for short and long-term complication rates and survival times between SUT and BAR groups.

Clinical Relevance—The BAR device can be used for colocolic anastomosis in cats with idiopathic megacolon. Serosal tearing during BAR insertion was a common intraoperative complication. Regardless of anastomotic technique, survival outcome after colonic resection is excellent for cats with FIM.

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INTRODUCTION

MEGACOLON IN cats can be primary (idiopathic, congenital) or secondary (pelvic fracture malunion, neurologic dysfunction, rectal stricture or neoplasia) in cause. Feline idiopathic megacolon (FIM) which accounts for 60–70% of reported cases, is believed to result from dysfunction of the colonic smooth muscle, although it is unknown if this is a primary or secondary effect. Medical management for FIM, typically a combination of fecal softeners, enemas, prokinetic agents and dietary modification, is generally unrewarding in the
long-term, and total or subtotal colectomy, with or without preservation of the ileocolic valve, is the recommended definitive treatment.

After subtotal colectomy, anastomosis can be achieved with sutures, staples, or a biofragmentable anastomotic ring (BAR; Valtrac™, US Surgical Corporation, Norwalk, CT; Fig 1). A single layer, simple interrupted, appositional sutured anastomosis has a low complication rate and is considered the current standard of care in veterinary surgery. A transcecal approach using an end to end anastomosis stapling instrument (EEA; US Surgical Corporation) to create an inverting anastomosis has been reported to yield an excellent outcome in cats with FIM; although the technique was associated with post operative bleeding in 2 cats and produces an additional staple line in the cecum.

The BAR was developed by Hardy et al in 1985 to create a sutureless, inverted anastomosis for enterectomy and colostomy in human patients. The BAR is composed of 87.5% polyglycolic acid and 12.5% barium sulfate. Inclusion of barium sulfate allows fragmentation and elimination of the BAR to be monitored radiographically. The BAR is available in a range of external diameters (25, 28, 31, 34 mm) and closed gap widths (1.5, 2.0, 2.5 mm) to accommodate different intestinal lumen diameters and wall thicknesses. One potential advantage of the BAR compared with stapling equipment is that it can be placed without an additional incision in the gastrointestinal tract or by retrograde introduction through the anus. BAR has been compared experimentally with sutured anastomosis after subtotal colectomy in young normal cats. Fragmentation occurred in a predictable manner 10–12 days after implantation and with BAR passage in the stool 2–5 days later without clinical signs. To our knowledge, there are no reported studies of BAR use in cats with FIM.

It is unknown if idiopathic megacolon has an influence on anastomotic healing after subtotal colectomy; however, the complication rate after subtotal colectomy and sutured anastomosis is very low. Because the BAR device is expelled relatively early during anastomosis healing, recommending use of the BAR device in these cats may be a potential concern. Thus, we conducted a retrospective study to report use of the BAR device in cats clinically affected by FIM to determine if there were any differences in operative, short- and long-term complication rates, clinical outcome, and survival by comparing these cats to a group of similarly affected cats that had sutured colocolostomy. Our null hypothesis was that there would be no difference in measured variables between the 2 anastomotic methods.

**MATERIAL AND METHODS**

**Inclusion Criteria**

Medical records (January 1990–January 2004) from a university teaching hospital and a referral practice were reviewed for cats that had surgical treatment for megacolon. Presumptive diagnosis of FIM was made based on historical findings, clinical signs, poor response to medical therapy, clinical examination findings, and preoperative abdominal radiography. Cats were included if they had subtotal colectomy and colocolostomy either by hand-suture (SUT) or use of a BAR device (BAR). A minimum follow-up of 4 months after surgery was required. Cats were excluded if the ileocolic valve was removed, if there was gastrointestinal tract neoplasia, or if it was determined that megacolon was secondary in nature.

**Data Retrieval**

Retrieved data were signalment, duration of clinical signs before surgery, previous medical treatment, anastomosis type (for sutured anastomosis [SUT], suture type, size, and pattern were recorded; for BAR, the external diameter and inner gap width of the BAR were recorded), preservation or removal of the ileocolic valve, primary surgeon training level, and any operative, short- or long-term complications.

Histologic findings were recorded if excised colon tissue was submitted for histopathology. Information on short- and long-term complications, and survival after surgery was obtained from either the medical record or telephone interview of the owner or referring veterinarian.

**Surgical Technique**

The decision to use the BAR device or suture was made before surgery. All BAR cases were performed by one surgeon.

Fig 1. Valtrac™ biofragmentable anastomosis ring (BAR) device with insertion tool.
Informed consent was obtained from clients before use of the BAR. Preoperative bowel preparation to remove feces from the colon was not performed. Either intravenous (IV) cefoxitin (22 mg/kg; 17 cats) or a combination (2 cats) of enrofloxacin (5 mg/kg IV) and amoxicillin (22 mg/kg IV) was administered before surgery and repeated every 90 minutes during surgery. Subtotal colectomy was performed after ventral midline celiotomy using a previously reported technique by a board-certified surgeon or a resident under direct supervision.

**BAR Anastomosis.** The BAR device was used according to manufacturer’s instructions and as described by Hardy et al.4 and Huss et al.6 Briefly, after isolating the affected colon, a 2–0 or 3–0 monofilament non-absorbable pursestring suture was placed across the colon just aboral to the cecum using a Furness clamp (Fig 2; US Surgical Corporation). A straight swaged needle was used for suture passage through the Furness clamp.3,6 The colon was then resected distal to the pursestring suture using the clamp as a guide. Another pursestring suture was placed in the terminal colon 2–3 cm proximal to the pelvic brim and the colon resected proximal to the second purse string suture. The pursestring sutures were inspected to ensure that they engaged the colon correctly.

The BAR device was introduced into the lumen of the orad segment of colon with the aid of a holding device and the pursestring suture tied securely against the internal barrel of the BAR device (Fig 3A). The smallest external diameter (25 mm) BAR device with a 1.5 mm gap width was used in all cats. If the colonic lumen was too small to accept the BAR, 1 mL papaverine (Papaverine HCl 30 mg/mL, Bedford Laboratories, Bedford, OH) was applied topically to relax the colonic wall smooth muscle and facilitate device insertion. After BAR insertion into the aboral colonic segment, the second purse string suture was secured (Fig 3B). The caps of the BAR device were digitally snapped shut from the serosal surface which engaged the full thickness of the colon to create an inverting anastomosis (Fig 3C). The anastomosis was carefully inspected to ensure circumferential serosa to serosa contact. At the discretion of the surgeon, an additional partial or complete continuous seromuscular suture was used to seal the anastomosis if serosal splitting occurred (Fig 3D).

**Sutured Anastomosis.** The affected colonic section was removed and an end to end anastomosis using a single layer appositional closure of either monofilament absorbable or non-absorbable material in either a simple interrupted or continuous pattern was used.

In all cats, the mesenteric defect was sutured closed. The abdomen was lavaged with warmed 0.9% saline (NaCl) solution and then the celiotomy closed.

**Outcome**

Operative, or short- and long-term postoperative complications were recorded. Short-term postoperative (within 2 weeks) complications were determined from the time after surgery to when first noted in the medical record. Long-term complications were defined as occurring between 2 weeks after surgery and death or follow-up time. Complications were further categorized as major or minor. Major complications were defined as those requiring general anesthesia and surgical intervention, or resulted in euthanasia. Minor complications were defined as those that responded to medical or conservative therapy.

Survival was defined as time (days) from surgery to either follow-up or death. If the cat was dead at follow-up, the reason for death was determined and recorded as related or not related to FIM or colectomy.

**Data Analysis**

Variables for the BAR and SUT groups were compared with a Fisher’s exact test for categorical data and ANOVA for continuous data. Results were reported as mean ± SEM. Kaplan–Meier actuarial survival analysis was used to compare short- and long-term complication rates and survival time between groups. If complications were related to FIM or surgery, the cat was uncensored for short- and long-term complication rate analysis. If death was related to FIM or surgery, the cat was uncensored in the survival analysis. A cat lost to follow-up, alive at the time of study, or dead for unrelated cause was censored for the survival and long-term complication rate analysis. A log-rank test was used to compare median complication rates and survival times. Power calculations were determined for comparisons between the BAR and SUT groups for short and long-term complication rates and survival time.10 A P value ≤ .05 was considered significant for all tests. Statistical analysis was performed with a statistical software package (JMP IN 5.1, SAS Institute Inc. Cary, NC).
RESULTS

Twenty seven cats with a presumptive diagnosis of megacolon that had surgical treatment were identified; 19 met the inclusion criteria. Twelve cats (8 BAR, 4 SUT) were from the university teaching hospital and 7 cats (all SUT) were from the referral practice. Thus, there were 11 SUT cats (5 female spayed, 6 male castrates) and 8 BAR (2 female spayed, 6 male castrates; \( P = .63 \)). The most common breed was the domestic short hair (\( n = 7 \)); breeds represented by 2 cats were: domestic long hair, Manx, Persian, and Russian Blue. No difference in mean age at surgery was detected (SUT \( = 9.70 \pm 1.10 \) years; range, 4.2–14.23 years; BAR \( = 9.60 \pm 1.3 \) years; range, 1.30–14.67 years; \( P = .98 \)).

All cats had a history of chronic constipation and had undergone various medical and dietary therapies before surgery. Multiple enemas had been performed in 7 BAR and in all SUT cats, lactulose was administered to 6 BAR and 8 SUT cats, and cisapride was administered to all BAR and 8 SUT cats. There was no difference in duration of signs before surgery for SUT (2.60 ± 0.70 years) and BAR groups (2.50 ± 0.80 years; \( P = .74 \)). Abdominal radiographs taken preoperatively in all cats confirmed presence of a dilated colon with fecal impaction, consistent with megacolon.

Surgery

The primary surgeon (EM, RB, HS) was a board-certified surgeon for 16 cats (8 SUT, 8 BAR) and a supervised resident (2 residents) for 2 cats (2 SUT).

Sutured Anastomosis. A single layer, appositional, end to end colocolic anastomosis was used in all cats; 10 cats had a simple interrupted pattern and 1 cat a simple continuous pattern. The cat with a continuous suture pattern developed a stricture at the anastomosis 32 days after surgery. Suture materials were all monofilament, either 3–0 (\( n = 8 \)) or 4–0 (\( n = 3 \)) size and either absorbable (polydioxanone, \( n = 8 \); polyglyconate, \( n = 2 \)) or non-absorbable (polypropylene, \( n = 1 \)). Two SUT cats had additional procedures performed at subtotal colectomy. One had 2 attempts at EEA stapling before sutured anastomosis was performed, and 1 had an enterectomy and end to end anastomosis for removal of granulomatous disease in the jejunum.

BAR Anastomosis. Mild longitudinal serosal tearing (2–3 mm in length, 1–2 tears) after BAR insertion
prompted use of an additional partial (1 cat) or complete (5 cats) continuous seromuscular reinforcing suture (3–0 polydioxanone, 2 cats; 4–0 polydioxanone, 4 cats) to prevent further tearing.

**Histopathology**

Histopathology was available for 10 cats (2 SUT, 8 BAR). No specific abnormalities suggesting an underlying cause for megacolon were detected. Changes either were non-specific and consistent with mild colitis (mild increase in number of goblet cells, flattening of mucosa), or the colon was considered within normal limits. Submucosal and myenteric ganglia were noted to be within normal limits for number and histomorphology.

**Complications**

No major intraoperative complications occurred in the SUT group. Difficulty inserting the BAR occurred in 6 cats resulting in mild serosal tearing and use of a seromuscular oversew suture. Topical papaverine was used in 3 BAR cats to relax the smooth muscle and dilate the lumen to allow easier BAR insertion; no oversew was required for 2 of these cats.

All cats recovered uneventfully and were hospitalized for a minimum of 2 days after surgery.

**Short-Term Complications.** Twelve cats had complications. Short-term complication rates at 3 and 7 days were 18% and 45% for SUT and 25% and 87.5% for BAR, respectively ($P = .058$, power = 0.40; Fig 4). Minor complications (11 cats) were anorexia (n = 6; 1 SUT, 5 BAR), anemia (3; 1 SUT, 2 BAR), and vomiting (2; 1 SUT, 1 BAR). One BAR cat had a major short-term complication: dehiscence occurred 36 hours after surgery causing septic peritonitis and the need for surgical intervention. One-third to one-half of the distal part of the anastomosis was not engaged between the BAR caps. The BAR device was removed and the colon anastomosed by simple interrupted suture reinforced by a serosal patch. This cat (not included in SUT after the second surgery) was discharged from the hospital and had no long-term complications. Postoperative body temperature $>39.5^\circ C$ did not occur in any cat during hospitalization except the dehiscence case.

**Long-Term Complications.** Six cats (4 SUT, 2 BAR) had long term complications. One and 4-year complication rates were both 41% for SUT and 25% for BAR ($P = .61$; power = 0.524; Fig 5). The most frequent minor long-term complication was continued soft stool consistency beyond 12 weeks (4 SUT, 1 BAR). Two SUT cats with persistent soft stool consistency had resolution of clinical signs with empirical treatment for inflammatory bowel disease; however, definitive diagnosis of inflammatory bowel disease was not made in either cat. The other minor long-term complication was recurrent constipation in 1 BAR cat. On abdominal radiographs there was mild dilation of the remaining colon 17 days after surgery. This cat had 1 enema and was treated with lactulose, dietary modification, and cisapride. After 1.5 years of daily treatment with lactulose, stool consistency and regular defecation could be maintained with dietary therapy alone. One SUT cat had a major long-term complication that required surgery. This cat developed a stricture at the anastomosis site that caused tenesmus and constipation. A continuous, single layer suture pattern (3–0 polyglyconate) was used at initial surgery and at 32 days, an end to side anastomosis was performed with a stapling instrument (Endo GIA and TA30 stapler, US Surgical Corporation).

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**Fig 4.** Survival curves for short-term complication rate. +, censored data; ■, uncensored data.

**Fig 5.** Survival curves for long-term complication rate. +, censored data; ■, uncensored data.
Follow-up was available on all cats; 12 cats were still alive. Median follow-up time was not significantly different between SUT (525 days) and BAR group (1041 days; $P = .27$). Five cats died or were euthanatized for reasons unrelated to either FIM or complications related to subtotal colectomy. One SUT cat was euthanatized for fecal incontinence and persistent soft stool consistency 254 days after surgery. One SUT cat was euthanatized for persistent soft stool consistency 1661 days after surgery. One and 4-year survival rates were both 90% for SUT and 100% for BAR ($P = .29$; power $= 0.16$; Fig 6).

DISCUSSION

A BAR device could be used for colocolic anastomosis after subtotal colectomy in cats clinically affected with idiopathic megacolon. Intraoperative complications were more frequent with BAR compared with a group of cats with FIM that had sutured anastomoses, however these were mostly minor and addressable at the time of surgery. Short- and long-term complication rates and survival times were not affected by use of the BAR compared with sutured anastomoses. Outcome after surgical treatment for idiopathic megacolon with either anastomotic technique was excellent. Subtotal colectomy can be considered curative for idiopathic megacolon.

In human patients, reported operative complication rates with BAR range from 4 to 17% and are higher than for sutured anastomoses. Complications related to BAR include mucosal or serosal tearing, failed pursestring application, and bowel lumen too small for the BAR. Serosal tearing after BAR insertion was the only intraoperative complication we observed. Tearing was longitudinal and affected the inverted part of the colon. In 6 cases, a continuous seromuscular oversew suture was used to prevent further tearing where serosal tearing occurred. This technique has been described in a human clinical trial and the BAR manufacturers recommend placing interrupted Lembert seromuscular sutures using absorbable monofilament sutures in deficient areas of the anastomosis. When serosal tearing did not occur, oversew of the anastomosis was not performed and no adverse effects were seen. Serosal or mucosal tearing was mostly caused by a large device size relative to the colonic lumen diameter.

Huss et al reported that in cadaveric normal cats oral colonic segment dimensions were marginal for insertion of a 25 mm BAR. Indeed, the oral colonic lumen was significantly smaller than the aboral lumen and more difficulty was encountered with BAR insertion in the oral segment. Kurdisch and Pavletic reported that, in cats with acquired megacolon, 25 mm circular staple cartridges could be used in 13 of 15 cats by a transrectal insertion route. We used the smallest available BAR (25 mm external diameter with a 1.5 mm gap size) based on the experience of Huss et al. Use of the BAR is limited to colocolic anastomosis as the 25 mm external diameter is too large for the feline terminal ileum, precluding its use for ileocolostomy.

After transection, colonic wall smooth muscle spasm leads to reduced lumen diameter which exacerbates difficulty of BAR insertion. Relaxation of colonic smooth muscle and lumen dilation can be used to facilitate BAR insertion, by warm saline irrigation, IV glucagon, topical 1% lidocaine, use of a water soluble sterile lubricant, insertion of ovoid sizing devices, manual dilation by forceps, and use of a Foley catheter balloon. We used the spasmolytic papaverine topically in 3 cats to relax the colonic smooth muscle. The lumen dilated within seconds of topical application. In 2 cats, BAR insertion was uneventful after papaverine use and in 1 cat mild serosal tearing still occurred. Further investigation of the use of papaverine for this purpose is warranted.

Postoperative dehiscence occurred in 1 BAR cat less than 36 hours after surgery. At the second surgery, the colon was partially free (one-third to half the circumference) from the distal BAR cap; failure of the pursestring suture was the most likely cause of anastomotic failure. Correct purse string suture placement is important for BAR anastomosis. Application of the Furness clamp and pursestring suture before colon transection reduces the risk of colon retraction within theclamp and inadequate pursestring purchase. Failure may also have occurred because of lack of colon compression by the BAR. As noted, we used a 1.5 mm gap BAR; however, in this
young cat the gap may have been too wide to adequately hold the colon wall. It is of interest that this cat only had a partial seromuscular oversew although the location of the oversew relative to the site of dehiscence was not recorded.

**Short-Term Complications**

Short-term complications occurred more frequently in the BAR group than the SUT group. These complications were mostly minor (anorexia, anemia) and were successfully managed with medical treatment. These complications in BAR cats may have resulted from inflammatory reaction and necrosis of the inverted colonic wall within the device. Increased body temperature and anorexia occurred postoperatively in 2 normal cats after BAR anastomosis between 7 and 15 days after surgery.6 Hyperthermia resolved with passage of the BAR. We did not observe hyperthermia in any of our BAR cases during hospitalization, but we cannot rule out that hyperthermia did not occur as the cats were at home during the expected BAR fragmentation period.

Soft stool consistency is an expected outcome after subtotal colectomy as the terminal ileum adapts to increase water absorption.15–17 so we did not classify soft stool consistency within the first 2 weeks as a short-term complication. Fecal consistency is expected to change to soft-formed stools by 12 weeks postoperatively.9,16,17

**Long-Term Complications**

Recorded long-term complications in both groups were similar to those previously reported. Complications occurred within the first year after surgery and were generally minor in nature. Recurrent constipation has been reported as a frequent (7–45%) long-term complication after sutured subtotal colectomy.9,16 BAR use results in retention of a longer colonic segment than in SUT which might increase the risk of recurrent constipation in cats with idiopathic megacolon. Only 1 BAR cat had recurrent constipation and this was managed with an enema, lactulose, cisapride, and dietary modification.

Stricture formation is a reported complication after colonic anastomosis.9 For sutured anastomoses, a single layer, simple interrupted, appositional suture pattern with monofilament absorbable or non-absorbable suture material is recommended for colonic anastomoses because 2-layer, crushing or inverting suture techniques are associated with an increased rate of stricture formation in dogs and cats.18 The BAR might increase risk of stricture formation. It produces an inverting anastomosis with reduction in luminal diameter and also induces an inflammatory reaction at the anastomosis site,6,19 because the entrapped tissue and pursestring sutures necrose and slough into the lumen, freeing the ring caps for expulsion. However, Huss et al6 reported no difference in granulation tissue, mucosal regeneration, or inflammation at the anastomosis site or distant inflammation between SUT and BAR anastomosis in normal cats. Similarly in comparative experimental studies in pigs and dogs, equivalent histological healing, with alignment of layers occurred by 16 days in most anastomoses performed by suture, staple, or BAR.4 Luminal diameter reduction was greater with BAR or stapled anastomosis than sutured anastomosis in dogs but gradually increased during the first 6 months.19 None of the BAR cats but 1 SUT cat developed stricture at the anastomosis site. Interestingly, this was the only cat that had a simple continuous pattern used for anastomosis.

Long-term, persistent soft-stool consistency occurred in 4 SUT cats and none of the BAR cats. Two cats responded to empirical treatment for inflammatory bowel disease, although this diagnosis was not confirmed. One cat was euthanatized at owner request 254 days after surgery because fecal incontinence was associated with the soft stool consistency. The other cat was euthanized 1661 days after surgery with the owner citing chronic soft-stool consistency as the reason for euthanasia.

**Colon Healing**

Although not evaluated in this report, it is of interest to consider comparative findings of healing after colon anastomosis with BAR or SUT. Colonic anastomoses have reduced collagen synthesis and greater collagen degradation compared with small intestinal anastomosis because of increased levels of collagenase produced under the influence of tissue inhibitor of metalloprotei-

nases.20–22 Anastomotic strength is reliant on the sutures, staples, or anastomotic devices during early (0–6 days) healing. Experimentally in dogs, bursting/leak pressure for BAR was lower, but not significantly so, than SUT anastomoses at 3 and 4 days and was equivalent to SUT by 7 days.19,23 Bursting pressures were greater for SUT than BAR anastomoses and both approached normal colonic bursting pressure by day 28. Wound breaking strength was significantly lower for BAR anastomosis at 4 and 7 days compared with sutured and stapled anastomosis but equivalent from 14 days onward.19

**Study Limitations**

We acknowledge several limitations to our study. Its retrospective nature over a 14-year period at 2 hospitals with various surgeons introduces many variables and potential biases that cannot be controlled. During that period some improvements in technique, especially with
BAR, occurred. Cases were not randomized to treatment groups, so surgeon bias in case selection is possible. Also owner recollections of postoperative complications, especially short-term complications, can be misleading in assessing complication rates. No radiographs were performed to document rate of degradation of the BAR device or document degree of luminal reduction.

In our study power was >0.4 for the complications rates. The power was low most likely because of the low case numbers. Although we analyzed comparative data, small sample sizes limited the power of our tests and therefore the strength of our conclusions. Ideally, a randomized clinical trial with larger population sizes comparing the 2 anastomotic methods should be done in cats affected by FIM.

Outcome

Overall short- and long-term complication rates, and survival times were not significantly different for BAR and SUT anastomoses. The difference between survival rates for the 2 techniques was only 10% at 4 years, which is likely not biologically significant. However, the short-term complication rate was higher in the BAR group and was considered biologically important. The difference in long-term complication rates between groups was only 6%. Even if differences were to become statistically significant with more cases, it would likely not be biologically significant.

Our results suggest the eventual outcome was similar in both BAR and SUT cats and that BAR offers no distinct advantage over sutured anastomosis. The intraoperative complication rate was higher with the BAR, but most complications were minor. BAR anastomoses are limited to colocolic anastomoses because of device size; a smaller sized BAR is not currently available. Our study did corroborate that regardless of anastomotic technique, outcome after colonic resection is excellent for cats with medically unresponsive idiopathic megacolon.

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