Title
A New Appendicostomy Technique to Prevent Stomal Stenosis.

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Author
Kurzrock, Eric A

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A new appendicostomy technique to prevent stoma stenosis

Running head: a new appendicostomy technique

Author:
Eric A. Kurzrock, M.D.
UC Davis Children's Hospital
Shriners Hospitals for Children – Northern California
4860 Y Street, #3500
Sacramento, CA 95817

Email: eakurzrock@ucdavis.edu

Phone: 916-734-4561

Fax: 916-734-8094

Abstract

Introduction

Stoma stenosis has been reported to occur in 12 to 45% of patients after ACE Malone and Mitrofanoff appendicostomy. The standard stoma technique entails excision of the distal appendix. Our goal was to determine if a novel technique with preservation of the appendiceal tip and vessels and opening the lumen in a more proximal and vascular area would decrease the incidence of stenosis.

Materials and Methods

Medical records from patients who underwent appendicostomy for ACE Malone or urinary diversion were retrospectively evaluated. Cases with a minimum of one year of follow-up and those in which the distal portion of a complete appendix was oriented for use as the stomal end in the umbilicus were included. Variables such as age, gender, BMI, ACE or urinary diversion, open or laparoscopic approach, cecal and appendiceal adhesions, retrocecal position, cecal imbrication, technique and stenosis were recorded. Cox proportional hazards analyses were performed to determine association of covariates.

Results

Inclusion criteria were met by 123 patients. The incidence of stenosis following standard stoma technique was 13% (12 of 93) with a median follow up of **9.4** years. Of these, 75% occurred within one year of surgery. Stoma stenosis has not occurred after the new stoma technique in 30 patients with a median follow up of 3.3 years. Only technique cohort, standard vs new, was associated with stenosis ($p=0.04$).

Conclusions

Stoma stenosis of appendicostomy may be lessened by preservation of the distal appendiceal vasculature and tip and opening the lumen in a more proximal location.

Introduction

Although considered vestigial, the vermiform appendix is a vital structure for urologic surgeons and their patients. The appendix typically has adequate length, lumen size and mobile vasculature to serve as a conduit. Thanks to pioneers in the field, notably Mitrofanoff and Malone,[1,2] we have been able to utilize the appendix for continent urinary diversion and delivery of antegrade colonic enemas (ACE), or sometimes both.

The standard technique for creation of an umbilical appendicostomy is to excise the appendiceal tip, spatulate anti-mesenteric and invert an inferior triangular skin flap into the spatulation. The superior edges of the appendiceal opening are sewn to the upper edge of umbilical skin. The most common complication after appendicostomy is stoma stenosis reported to occur between 12 and 45% of patients.[3–12] A testament to the high incidence of stenosis is the preponderance of stoma techniques. Most of these are directed to non-umbilical stomas with creation of skin flaps that drop below the skin surface such that the mucosa is hidden.[13,14]

For umbilical stomas, the inferior V-flap is generally soft, mobile and well perfused similar to skin used in non-umbilical stomas. On the other hand, the posterior umbilical skin is usually hard and tough. In 2000, the author found that complete excision of posterior umbilical skin provides for an easier anastomosis without compromising the appearance of the hidden stoma. With the goal to lessen stenosis in 2012 the author stopped resecting the end of the appendix and employed the principle of a loop ileostomy and ureterostomy which ensures better vascularization.[15] Unlike a loop ileostomy a knuckle of bowel is not formed. The distal end of the appendix is kept above the fascia with preservation of the appendiceal tip and vessels and creation of the stoma more proximal.

In addition to stoma technique, there are other patient, anatomic and surgical variables that might associate with stenosis such as age, obesity, extensive mesenteric mobilization, “de-hinging” a twisted appendix and cecal imbrication. The goal of this retrospective study was to determine if any of these factors or appendicostomy technique were associated with stenosis.

Methods

Beginning January 2000, “standard” appendiceal stoma formation was performed by fashioning a V-flap from the inferior umbilical skin, resection of the posterior umbilical skin, delivery of the appendix through a fascial incision just inferior to the umbilicus, ligation of the appendiceal artery at the desired length, excision of the distal appendix, antimesenteric spatulation and then maturation to the inverted flap of umbilical skin with interrupted 5-0 polyglactin suture. A catheter was left in place for 4 weeks, followed by institution of intermittent catheterization.

In 2012 the new appendicostomy technique was initiated (Fig. 1). After fashioning a triangular skin flap and excising the posterior skin as described above, the superior umbilical skin is retracted anteriorly. By gentle spreading under the fat, the fascia is exposed and a small space is created superior to the umbilicus. A 5-0 polyglactin suture is placed in the fascia at the top of the space. The appendix is brought through the fascial incision inferior to the umbilicus and the tip secured to the fascia above the umbilicus (Fig. 2). A sagittal incision is made on the anterior antimesenteric appendix opening the lumen from mid umbilicus to below the umbilicus. The skin flap is sewn into the lower aspect of the opening. The lateral and superior edges of the appendiceal opening are sewn to the pliable undermined umbilical skin edges.

The stoma technique was not changed based upon surgical approach, open vs laparoscopic. For open cases the cecum (for ACE) or bladder (for urine diversion) was secured to the anterior abdominal wall after stoma completion.

After IRB approval (591176), medical records from patients who underwent appendicostomy for ACE Malone or urinary diversion between 2000 and 2018 were evaluated. Only cases with a minimum of one year of follow-up and those in which the distal portion of a complete appendix was oriented for use as the stomal end in the umbilicus were included. Patients who had a non-umbilical stoma were excluded to isolate the impact of the technical modification which was limited to umbilical stomas. Patients with split appendix or cecal-extension technique were excluded.

Variables that were recorded included date of surgery, age at surgery, gender, BMI, ACE or urinary diversion, surgical approach (laparoscopic or open), appendiceal position (retrocecal or not), need to excise appendiceal adhesions, cecal imbrication, stoma location, stoma technique and follow-up time. BMI **(based on weight and height)** and percentiles were calculated using the CDC calculator (https://www.cdc.gov). Patients were categorized as normal, overweight (85-94 percentile) or obese (95-99 percentile). Stoma stenosis was defined as difficulty placing a catheter that required either long-term catheter (stopper) use and/or revision. Dates of first occurrence of stenosis and revision were recorded.

Patient and surgery characteristics were compared using Wilcoxon rank sum tests for continuous variables and Fisher’s Exact Test for categorical variables. Time to stenosis was modelled by patient and surgery characteristics using Cox proportional hazards models. Models were fitted using Firth bias-reduced maximum likelihood [1], as some variable levels had no stenoses. Analyses were conducted using R version 3.6.1 (2019-07-05). Firth bias-reduced maximum likelihood was fitted using the R package coxphf, version 1.13.

Results

Over the 19-year period 123 patients (93 standard stoma, 30 new stoma) fit the inclusion criteria of which 113 patients had neuropathic disease. Four had history of posterior urethral valves, two with prune belly syndrome, two with bilateral ectopic ureters with outlet dysfunction, and two with prostatic rhabdomyosarcoma.

After initial laparoscopic ACE surgery, two patients had repurposing of the appendix to an appendico-vesicostomy at 5 and 10 years. Two patients with a standard stoma stopped using the ACE at 5 and 8 years; their follow up period was recorded as those dates. Six patients, all with a standard stoma, were excluded. Two moved within a year of surgery. One patient was non-compliant within six months of surgery. Two were excluded due to difficult catheterization proximal to the stoma, one due to appendico-cecal angulation and one due to a “crunchy” appendiceal lumen found during surgery that persisted after the catheter was removed.

Patient, anatomical and surgical variables are detailed in Table 1. All data points were available except seven height measurements. Among the variables, there was no significant difference between the cohorts. At time of surgery, 52% of patients were overweight or obese. Obesity was more prevalent in the new stoma patients but not a statistically significant difference.

The incidence of stenosis after standard-stoma surgery was 13% (12 of 93) with a median follow up of 9.4 years. Of these, 66% occurred within 6 months and 75% within one year of surgery (Fig. 3 KM curves). Some patients with stenosis used a stopper or indwelling catheter until corrective surgery. Revision surgeries were performed 2 to 13 months after first occurrence and all but one have been free of stenosis for 4 to 17 years after revision.

After the new stoma technique, no patient has had stenosis with a median follow up of 3.3 years. Although stenosis was defined as difficulty placing a catheter that required either long-term catheter (or stopper) use and/or revision, no patient has required dilation or steroids.

Cox proportional hazard models (Table 2) showed no association of stenosis with patient, anatomic or surgical variables except stoma technique ($p=0.04$). Patients with a new stoma had 8-fold lower hazard of stenosis than patients with a standard stoma, hazard ratio 0.125 (CI 95%, 0.00, 0.95).

There has been no morbidity from the preservation of the distal tip nor can it be palpated or appreciated on physical examination. Although not objectively analyzed, the author has not found any difference in appearance of the umbilical stomas which are nearly impossible to visualize without probing the deep umbilicus.

Discussion

In 1980 Mitrofanoff described the utility of the appendix for urinary diversion in 16 patients.[1] The distal tip of the appendix was excised and implanted into the bladder with the wider cecal end preserved for a stoma. Ten years later, Malone et al described appendicostomy for fecal dysfunction with detachment and reversal of the appendix and placement into a cecal tunnel.[2] The stoma was created in the RLQ by fashioning a skin tube sewn to the cecal cuff. Later, Mr. Malone authored another case series (21 patients) entitled the Malone antegrade continence enema enshrining the eponym.[16] Modifications included leaving the appendix *in situ* with excision of the tip and spatulation. Unfortunately, more than half had stomal stenosis or breakdown presaging future outcomes that we see today. Contemporary large series demonstrate stenosis in 12 to 45% of patients.[3–12,17,18] Some institutions have recommended leaving a “stopper” in place for 6 months or forever.[19]

In this analysis we have tried to evaluate every known variable that has been associated with stenosis. Yet, the most important is time. Most long term studies that have evaluated time showed a median time to stenosis of less than one year.[5,8,20] It has been postulated that later occurrences may be due to unreported periods of non-compliance. In the present study a minimum of one year of follow up was required for inclusion. Of those with stenosis (8 of 12) 66% occurred within 6 months and (9 of 12) 75% within one year of surgery (Fig. 2 KM curves). Two cases occurred more than 3 years after surgery. Whether these later occurrences were due to non-compliance could not be determined.

A number of patient and technical variables that may contribute to stenosis have been evaluated in other studies. These include age, obesity, compliance, stoma location and cecal imbrication. Results have been contradictory. One study found increased age at surgery associated with stenosis.[17] On the other hand, two others found no association with age.[18,20] In the present study patients **with the new stoma technique** were on average 2 years older at time of surgery. Cox proportional hazards analysis of time to stenosis including all measured variables did not show age was associated with stenosis (P=0.89).

Over 40% of patients with spina bifida are overweight or obese. The appropriate measurement tool for BMI in patients with spina bifida is controversial due to lower limb hypoplasia and vertebral anomalies. Height is suitable for lower level lesions whereas arm length and other anthropometric measurements improve accuracy for thoracic level.[21,22] In our population of patients, which included non-neuropathic patients, over 50% were overweight or obese at time of surgery. At least four institutions have analyzed obesity as a risk factor for stenosis with contradictory results.[9,17,23,24] These studies also included non-appendiceal conduits. Standard BMI calculations with height were used but categorization of obesity differed. In the present study neither obesity nor overweight status was associated with stenosis.

Our preference is to place stomas in the umbilicus since it is a thin exit point from the abdomen and can be hidden. Some patients cannot have an umbilical stoma due to anatomy or placement of two stomas. Others have not found location of the stoma to be associated with stenosis.[8,9,17] Cecal plication has been considered critical for stomal continence by some, although Malone suggested it may not be necessary.[16] Our group has studied the association of imbrication with stomal continence and proposed a grading system.[25,26] Despite potential effects upon perfusion, this study and one other did not find an association between cecal imbrication and stenosis.[20]

The Indiana group has written extensively on ACE Malone and urinary diversion. In their large experience they did not find an association between stoma location and stenosis. A salient quote from their studies, “Potential technical causes contributing to stomal stenosis are excessive tension on the mucocutaneous anastomosis and/or poor blood supply to distal appendix or skin flap.”[8] The presented technique might alleviate these two causes. The superior holding stitch prevents tension on the anastomosis during the healing phase when the patient moves. Since the distal appendix is not used for the stoma and the blood supply is never violated, perfusion is ensured.

Date of surgery, chronology, was included in the analysis to determine if there was a learning curve. During the 12 years of application of the standard stoma, the 12 cases of stenosis were evenly distributed. Statistical analysis did not find date of surgery associated with stenosis. This study is limited by its retrospective nature and lack of randomization. A single surgeon experience carries inherent biases of technique and could be an advantage or disadvantage when evaluating an isolated technical change. Although every known variable that could impact stenosis was evaluated, there are certainly factors that are unknown.

Conclusion

Similar to other studies, this analysis did not show an association of patient age, BMI, sex or cecal imbrication with stenosis. Other variables that have not been previously evaluated such as appendiceal position, adhesions and approach were not found to impact incidence of stenosis. The only factor that was found to associate with stenosis was procedural completion with the standard vs new technique. Stoma stenosis of appendicostomy may be lessened by preservation of the distal appendiceal vasculature and tip and opening the lumen more proximal.

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