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A new appendicostomy technique to prevent stoma stenosis

Running head: a new appendicostomy technique

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47**Abstract**

48

49**Introduction**

50Stoma stenosis has been reported to occur in 12 to 45% of patients after ACE
51Malone and Mitrofanoff appendicostomy. The standard stoma technique
52entails excision of the distal appendix. Our goal was to determine if a novel
53technique with preservation of the appendiceal tip and vessels and opening
54the lumen in a more proximal and vascular area would decrease the
55incidence of stenosis.

56

57**Materials and Methods**

58Medical records from patients who underwent appendicostomy for ACE
59Malone or urinary diversion were retrospectively evaluated. Cases with a
60minimum of one year of follow-up and those in which the distal portion of a
61complete appendix was oriented for use as the stomal end in the umbilicus
62were included. Variables such as age, gender, BMI, ACE or urinary diversion,
63open or laparoscopic approach, cecal and appendiceal adhesions, retrocecal
64position, cecal imbrication, technique and stenosis were recorded. Cox
65proportional hazards analyses were performed to determine association of
66covariates.

67

68**Results**

69Inclusion criteria were met by 123 patients. The incidence of stenosis
70following standard stoma technique was 13% (12 of 93) with a median follow
71up of **9.4** years. Of these, 75% occurred within one year of surgery. Stoma
72stenosis has not occurred after the new stoma technique in 30 patients with
73a median follow up of 3.3 years. Only technique cohort, standard vs new,
74was associated with stenosis ($p=0.04$).

75

76**Conclusions**

77Stoma stenosis of appendicostomy may be lessened by preservation of the
78distal appendiceal vasculature and tip and opening the lumen in a more
79proximal location.

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98**Introduction**

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100Although considered vestigial, the vermiform appendix is a vital structure for
101urologic surgeons and their patients. The appendix typically has adequate
102length, lumen size and mobile vasculature to serve as a conduit. Thanks to
103pioneers in the field, notably Mitrofanoff and Malone,^{1,2} we have been able to
104utilize the appendix for continent urinary diversion and delivery of antegrade
105colonic enemas (ACE), or sometimes both.

106

107The standard technique for creation of an umbilical appendicostomy is to
108excise the appendiceal tip, spatulate anti-mesenteric and invert an inferior
109triangular skin flap into the spatulation. The superior edges of the
110appendiceal opening are sewn to the upper edge of umbilical skin. The most
111common complication after appendicostomy is stoma stenosis reported to
112occur between 12 and 45% of patients.³⁻¹² A testament to the high incidence
113of stenosis is the preponderance of stoma techniques. Most of these are
114directed to non-umbilical stomas with creation of skin flaps that drop below
115the skin surface such that the mucosa is hidden.^{13,14}

116

117For umbilical stomas, the inferior V-flap is generally soft, mobile and well
118perfused similar to skin used in non-umbilical stomas. On the other hand, the
119posterior umbilical skin is usually hard and tough. In 2000, the author found
120that complete excision of posterior umbilical skin provides for an easier
121anastomosis without compromising the appearance of the hidden stoma.
122With the goal to lessen stenosis in 2012 the author stopped resecting the
123end of the appendix and employed the principle of a loop ileostomy and
124ureterostomy which ensures better vascularization.¹⁵ Unlike a loop ileostomy
125a knuckle of bowel is not formed. The distal end of the appendix is kept
126above the fascia with preservation of the appendiceal tip and vessels and
127creation of the stoma more proximal.

128

129In addition to stoma technique, there are other patient, anatomic and
130surgical variables that might associate with stenosis such as age, obesity,
131extensive mesenteric mobilization, “de-hinging” a twisted appendix and
132cecal imbrication. The goal of this retrospective study was to determine if
133any of these factors or appendicostomy technique were associated with
134stenosis.

135

136

137**Methods**

138

139Beginning January 2000, “standard” appendiceal stoma formation was
140performed by fashioning a V-flap from the inferior umbilical skin, resection of
141the posterior umbilical skin, delivery of the appendix through a fascial
142incision just inferior to the umbilicus, ligation of the appendiceal artery at the
143desired length, excision of the distal appendix, antimesenteric spatulation
144and then maturation to the inverted flap of umbilical skin with interrupted 5-
1450 polyglactin suture. A catheter was left in place for 4 weeks, followed by
146institution of intermittent catheterization.

147

148In 2012 the new appendicostomy technique was initiated (Fig. 1). After
149fashioning a triangular skin flap and excising the posterior skin as described
150above, the superior umbilical skin is retracted anteriorly. By gentle spreading
151under the fat, the fascia is exposed and a small space is created superior to
152the umbilicus. A 5-0 polyglactin suture is placed in the fascia at the top of
153the space. The appendix is brought through the fascial incision inferior to the
154umbilicus and the tip secured to the fascia above the umbilicus (Fig. 2). A
155sagittal incision is made on the anterior antimesenteric appendix opening
156the lumen from mid umbilicus to below the umbilicus. The skin flap is sewn
157into the lower aspect of the opening. The lateral and superior edges of the
158appendiceal opening are sewn to the pliable undermined umbilical skin
159edges.

160

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

165

166After IRB approval (591176), medical records from patients who underwent
167appendicostomy for ACE Malone or urinary diversion between 2000 and 2018
168were evaluated. Only cases with a minimum of one year of follow-up and
169those in which the distal portion of a complete appendix was oriented for use
170as the stomal end in the umbilicus were included. Patients who had a non-
171umbilical stoma were excluded to isolate the impact of the technical
172modification which was limited to umbilical stomas. Patients with split
173appendix or cecal-extension technique were excluded.

174

175Variables that were recorded included date of surgery, age at surgery,
176gender, BMI, ACE or urinary diversion, surgical approach (laparoscopic or
177open), appendiceal position (retrocecal or not), need to excise appendiceal
178adhesions, cecal imbrication, stoma location, stoma technique and follow-up
179time. BMI (**based on weight and height**) and percentiles were calculated
180using the CDC calculator (<https://www.cdc.gov>). Patients were categorized as
181normal, overweight (85-94 percentile) or obese (95-99 percentile). Stoma
182stenosis was defined as difficulty placing a catheter that required either long-
183term catheter (stopper) use and/or revision. Dates of first occurrence of
184stenosis and revision were recorded.

185

186Patient and surgery characteristics were compared using Wilcoxon rank sum
187tests for continuous variables and Fisher's Exact Test for categorical
188variables. Time to stenosis was modelled by patient and surgery
189characteristics using Cox proportional hazards models. Models were fitted
190using Firth bias-reduced maximum likelihood [1], as some variable levels had
191no stenoses. Analyses were conducted using R version 3.6.1 (2019-07-05).
192Firth bias-reduced maximum likelihood was fitted using the R package
193coxphf, version 1.13.

194

195

196Results

197

198Over the 19-year period 123 patients (93 standard stoma, 30 new stoma) fit
199the inclusion criteria of which 113 patients had neuropathic disease. Four
200had history of posterior urethral valves, two with prune belly syndrome, two
201with bilateral ectopic ureters with outlet dysfunction, and two with prostatic
202rhabdomyosarcoma.

203

204After initial laparoscopic ACE surgery, two patients had repurposing of the
205appendix to an appendico-vesicostomy at 5 and 10 years. Two patients with
206a standard stoma stopped using the ACE at 5 and 8 years; their follow up
207period was recorded as those dates. Six patients, all with a standard stoma,
208were excluded. Two moved within a year of surgery. One patient was non-
209compliant within six months of surgery. Two were excluded due to difficult
210catheterization proximal to the stoma, one due to appendico-cecal
211angulation and one due to a "crunchy" appendiceal lumen found during
212surgery that persisted after the catheter was removed.

213

214Patient, anatomical and surgical variables are detailed in Table 1. All data
215points were available except seven height measurements. Among the
216variables, there was no significant difference between the cohorts. At time of
217surgery, 52% of patients were overweight or obese. Obesity was more
218prevalent in the new stoma patients but not a statistically significant
219difference.

220

221The incidence of stenosis after standard-stoma surgery was 13% (12 of 93)
222with a median follow up of 9.4 years. Of these, 66% occurred within 6
223months and 75% within one year of surgery (Fig. 3 KM curves). Some
224patients with stenosis used a stopper or indwelling catheter until corrective
225surgery. Revision surgeries were performed 2 to 13 months after first
226occurrence and all but one have been free of stenosis for 4 to 17 years after
227revision.

228

229After the new stoma technique, no patient has had stenosis with a median
230follow up of 3.3 years. Although stenosis was defined as difficulty placing a
231catheter that required either long-term catheter (or stopper) use and/or
232revision, no patient has required dilation or steroids.

233

234Cox proportional hazard models (Table 2) showed no association of stenosis
235with patient, anatomic or surgical variables except stoma technique
236($p=0.04$). Patients with a new stoma had 8-fold lower hazard of stenosis than
237patients with a standard stoma, hazard ratio 0.125 (CI 95%, 0.00, 0.95).

238

239There has been no morbidity from the preservation of the distal tip nor can it
240be palpated or appreciated on physical examination. Although not
241objectively analyzed, the author has not found any difference in appearance
242of the umbilical stomas which are nearly impossible to visualize without
243probing the deep umbilicus.

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245

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247Discussion

248

249In 1980 Mitrofanoff described the utility of the appendix for urinary diversion
250in 16 patients.¹ The distal tip of the appendix was excised and implanted into
251the bladder with the wider cecal end preserved for a stoma. Ten years later,
252Malone et al described appendicostomy for fecal dysfunction with
253detachment and reversal of the appendix and placement into a cecal tunnel.²
254The stoma was created in the RLQ by fashioning a skin tube sewn to the
255cecal cuff. Later, Mr. Malone authored another case series (21 patients)
256entitled the Malone antegrade continence enema enshrining the eponym.¹⁶
257Modifications included leaving the appendix *in situ* with excision of the tip
258and spatulation. Unfortunately, more than half had stomal stenosis or
259breakdown presaging future outcomes that we see today. Contemporary
260large series demonstrate stenosis in 12 to 45% of patients.^{3-12,17,18} Some
261institutions have recommended leaving a “stopper” in place for 6 months or
262forever.¹⁹

263

264

265In this analysis we have tried to evaluate every known variable that has been
266associated with stenosis. Yet, the most important is time. Most long term
267studies that have evaluated time showed a median time to stenosis of less
268than one year.^{5,8,20} It has been postulated that later occurrences may be due
269to unreported periods of non-compliance. In the present study a minimum of
270one year of follow up was required for inclusion. Of those with stenosis (8 of
27112) 66% occurred within 6 months and (9 of 12) 75% within one year of
272surgery (Fig. 2 KM curves). Two cases occurred more than 3 years after
273surgery. Whether these later occurrences were due to non-compliance could
274not be determined.

275

276A number of patient and technical variables that may contribute to stenosis
277have been evaluated in other studies. These include age, obesity,
278compliance, stoma location and cecal imbrication. Results have been
279contradictory. One study found increased age at surgery associated with
280stenosis.¹⁷ On the other hand, two others found no association with age.^{18,20}
281In the present study patients **with the new stoma technique** were on
282average 2 years older at time of surgery. Cox proportional hazards analysis
283of time to stenosis including all measured variables did not show age was
284associated with stenosis (P=0.89).

285

286Over 40% of patients with spina bifida are overweight or obese. The
287appropriate measurement tool for BMI in patients with spina bifida is
288controversial due to lower limb hypoplasia and vertebral anomalies. Height is
289suitable for lower level lesions whereas arm length and other anthropometric
290measurements improve accuracy for thoracic level.^{21,22} In our population of
291patients, which included non-neuropathic patients, over 50% were
292overweight or obese at time of surgery. At least four institutions have
293analyzed obesity as a risk factor for stenosis with contradictory results.^{9,17,23,24}
294These studies also included non-appendiceal conduits. Standard BMI
295calculations with height were used but categorization of obesity differed. In
296the present study neither obesity nor overweight status was associated with
297stenosis.

298

299Our preference is to place stomas in the umbilicus since it is a thin exit point
300from the abdomen and can be hidden. Some patients cannot have an
301umbilical stoma due to anatomy or placement of two stomas. Others have
302not found location of the stoma to be associated with stenosis.^{8,9,17} Cecal
303plication has been considered critical for stomal continence by some,
304although Malone suggested it may not be necessary.¹⁶ Our group has studied
305the association of imbrication with stomal continence and proposed a
306grading system.^{25,26} Despite potential effects upon perfusion, this study and
307one other did not find an association between cecal imbrication and
308stenosis.²⁰

309

310The Indiana group has written extensively on ACE Malone and urinary
311diversion. In their large experience they did not find an association between
312stoma location and stenosis. A salient quote from their studies, "Potential
313technical causes contributing to stomal stenosis are excessive tension on the
314mucocutaneous anastomosis and/or poor blood supply to distal appendix or
315skin flap."⁸ The presented technique might alleviate these two causes. The
316superior holding stitch prevents tension on the anastomosis during the
317healing phase when the patient moves. Since the distal appendix is not used
318for the stoma and the blood supply is never violated, perfusion is ensured.

319
320Date of surgery, chronology, was included in the analysis to determine if
321there was a learning curve. During the 12 years of application of the
322standard stoma, the 12 cases of stenosis were evenly distributed. Statistical
323analysis did not find date of surgery associated with stenosis. This study is
324limited by its retrospective nature and lack of randomization. A single
325surgeon experience carries inherent biases of technique and could be an
326advantage or disadvantage when evaluating an isolated technical change.
327Although every known variable that could impact stenosis was evaluated,
328there are certainly factors that are unknown.

329

330

331**Conclusion**

332

333Similar to other studies, this analysis did not show an association of patient
334age, BMI, sex or cecal imbrication with stenosis. Other variables that have
335not been previously evaluated such as appendiceal position, adhesions and
336approach were not found to impact incidence of stenosis. The only factor
337that was found to associate with stenosis was procedural completion with the
338standard vs new technique. Stoma stenosis of appendicostomy may be
339lessened by preservation of the distal appendiceal vasculature and tip and
340opening the lumen more proximal.

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344**Acknowledgement**

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