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Evaluating the Relationship Between Nutrition and Post-colectomy Pouchitis in Pediatric Patients with Ulcerative Colitis

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Abstract

Background—Pouchitis is the most frequent complication following restorative proctocolectomy and ileal pouch anal anastomosis (RP-IPAA) in patients with Ulcerative colitis (UC). Pediatric data on nutritional status during RP-IPAA and in patients with pouchitis are limited.

Aims—We aimed to delineate nutritional changes in children undergoing 2-stage and 3-stage surgeries and to evaluate the association between nutrition and the development of recurrent or chronic pouchitis.

Methods—This single-center retrospective study involved 46 children with UC who underwent a RP-IPAA. Data were collected at each surgical stage and for up to 2-year post-ileostomy takedown. We used Wilcoxon matched-pairs signed-rank test to evaluate the differences in nutritional markers across surgical stages and logistic regression to identify the factors associated with recurrent or chronic pouchitis.

Results—Twenty patients (43.5%) developed recurrent or chronic pouchitis. Children who underwent a 3-stage procedure had improvements in albumin, hematocrit, and body mass index (BMI)-for-age *Z*-scores ($p < 0.01$) between the first two stages. A positive trend in BMI-for-age *Z*-scores ($p = 0.08$) was identified in children with 2-stage procedures. All patients showed sustained nutritional improvement during the follow-up period. Among patients who underwent 3-stage surgeries, BMI worsened by 0.8 standard deviations (SDs) ($p = 0.24$) between the initial stages in those who developed recurrent or chronic pouchitis and improved by 1.1 SDs ($p = 0.04$) in those who did not.

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Author's contribution PVP contributed to conception and design of the project, was the primary author of the manuscript, conducted data analysis, and contributed to interpretation of the data. EK contributed to design of the project, was essential in data extraction, and was an editor for the manuscript. ES contributed to design of the project, was essential in data extraction, and was an editor for the manuscript. MBH contributed to the design of the project and interpretation of the data, and was an editor for the manuscript. LV contributed to conception and design of the project, contributed to interpretation of the data, and was an editor for the manuscript. SGV contributed to the conception and design of the project, contributed to interpretation of the data, and was an editor for the manuscript.

Conflict of interest None.

Conclusions—Early improvement in BMI-for-age *Z*-scores following the initial stage was associated with lower rates of recurrent or chronic pouchitis. Larger prospective studies are needed to validate these findings.

Keywords

Pediatrics; Ulcerative colitis; Colectomy; Pouchitis; Ileal pouch anal anastomosis; Body mass index

Introduction

Colectomy rates in pediatric patients with Ulcerative colitis (UC) range from 20 to 40% within 10 years of diagnosis [1, 2]. Restorative proctocolectomy and ileal pouch anal anastomosis (RP-IPAA) is the procedure of choice to restore of intestinal continuity for these patients [3, 4]. Surgical intervention is a curative option associated with improved quality of life, reduced symptoms, and improved control of bowel movements [3-5]. Pouchitis is the most common post-surgical complication of RP-IPAA, occurring in up to 50% of pediatric patients within 5 years after surgery [6-10].

Few studies are published on nutritional and growth outcomes following RA-IPAA in children with UC, and no study has evaluated the relationship between nutrition and the risk for pouchitis. A recent pediatric study following anthropometric measurements shows positive trends, but no statistically significant differences, using a median follow-up time of 11 months post-IPAA [4]. Nicholls et al. showed improved height velocity, primarily in pre-adolescent patients, using a small group of patients with UC who had only undergone the initial stage of sub-total colectomy with ileostomy and rectal remnant with a mucus fistula [11]. A prospective study showed significant improvement in body mass index (BMI), albumin, hematocrit, and skeletal muscle index along with a decrease in the prevalence of sarcopenia following colectomy in a group of adult patients with UC [12]. Our study had 2 aims: (1) to characterize the progression of perioperative nutritional changes using serum and biophysical data and (2) to determine if nutritional status during the surgical stages was associated with a lower incidence of chronic or recurrent pouchitis.

Methods

Study Design and Patients

This single-center retrospective cohort study included 46 pediatric patients with UC who underwent a RP-IPAA at the University of California San Francisco (UCSF) Benioff Children's Hospital from January 2008 to July 2021. All patients had a 2-stage or 3-stage procedure and were considered emergent cases based on chart review. The choice of 2-stage versus 3-stage was based on the surgeon's discretion, which encompassed his/her training and comfort and consideration of the patient's health status. We excluded elective cases and single-stage surgeries as they are generally reserved for ambulatory, clinically well patients. Patients with Crohn's Disease or Inflammatory Bowel Disease Undifferentiated were excluded from the study. Patients underwent their surgeries at UCSF Benioff Children's Hospitals San Francisco and Oakland locations and were subsequently

followed by providers in the hospital's Pediatric Surgery Department and the Pediatric Inflammatory Bowel Disease Program.

We collected demographic data (gender, race, ethnicity, date of birth); disease information (age at diagnosis, Paris Classification [13], UC medication history); and surgical course (date of each stage of surgery, pre-operative corticosteroid use, stapled versus handsewn ileoanal anastomosis, and episodes of pouchitis) using the electronic medical record. To trend nutritional status, we utilized a combination of both biophysical and laboratory data. Body mass index (BMI)-for-age *Z*-scores and serum markers (albumin and hematocrit) were obtained prior to each surgery and for up to 2-year post-ileostomy takedown. Post-takedown follow-up time points were divided into 3–6 months and 1–2 years; if patients had multiple visits or laboratory values obtained during those time periods, the average values were determined. An internal institutional review board approved this study.

Study Definitions

RP-IPAA Surgical Stages—The two-stage surgery entailed a proctocolectomy with creation of the loop ileostomy with J-pouch creation during the initial operation, followed by ileostomy takedown. The three-stage surgery consisted of a sub-total colectomy and end ileostomy in the first step, completion proctectomy with ileal pouch and diverting loop ileostomy in the second step, and takedown of the loop ileostomy in the third step [14].

We grouped the initial operation for both procedures (2-stage and 3-stage surgeries) into 'Stage 1'. We grouped the ileostomy takedown for both procedures into 'Stage 3'. We reserved 'Stage 2' for the completion proctocolectomy and loop ileostomy creation that was done in the three-stage operation.

Nutritional Markers—In the absence of a gold standard for the definition and evaluation of malnutrition, we used the surrogate markers of hematocrit, albumin, and BMI-for-age *Z*-scores to evaluate patients' nutritional status. Previous studies suggest a role for these biomarkers as a component of nutritional evaluation [15, 16]. Hematocrit and albumin are associated with malnutrition in hospitalized adult patients, including in patients with chronic inflammation [15]. Hypoalbuminemia, low BMI, and malnutrition are associated with increased risk of post-operative complications, and anemia has been described as an aspect of malnutrition in patients with inflammatory bowel disease (IBD) [17-20]. The most common etiology of anemia in pediatric patients with IBD is iron deficiency, which occurs in up to 58% of children with IBD [21]. We defined hypoalbuminemia as an albumin level < 3.5 g/dL and used gender and age-specific criteria for anemia per our institution's lab [22].

Pouchitis—The diagnosis of pouchitis is complicated by varying diagnostic criteria and non-specific symptoms that may overlap with other diseases or pouch-related problems [23]. Based on previous studies, we divided pouchitis cases into acute, recurrent, and chronic pouchitis [8]. Patients with acute pouchitis had symptoms that lasted ≤ 4 weeks and were alleviated with antibiotics. Patients with recurrent pouchitis experienced at least 3 separate bouts of pouchitis within a 1-year period, with return to baseline between episodes. Those with chronic pouchitis had symptom duration > 4 consecutive weeks or required long-term therapy including antibiotics, corticosteroids, 5-aminosalicylic acids, or biologic agents [6,

8, 24]. Pouch endoscopy to confirm diagnosis was performed based upon discretion of the treating gastroenterologist.

Statistical Analyses

Chi-squared tests and Wilcoxon rank-sum tests were used to analyze the differences at baseline between patients who developed chronic or recurrent pouchitis versus those who did not. Non-parametric testing was applied given small sample sizes and lack of normal distribution. Variables describing the time between surgical stages were presented using median and interquartile range (IQR) as they were not normally distributed. Changes in continuous measures were compared using Wilcoxon matched-pairs signed-rank test. Logistic regression was utilized to determine the association between changes in nutritional variables and the development of chronic or recurrent pouchitis. Key adjustment variables, selected based on content expertise, included disease characteristics (age at diagnosis, Paris Classification, ileitis, time from diagnosis to surgery), demographics (gender, ethnicity), corticosteroid use at colectomy, laboratory tests at colectomy (hematocrit and albumin), number of stages, and anastomosis type. Data were stored in a secure REDCap server. Analyses were conducted using STATA 16.0 (College Station, TX) [25]. Statistical significance was accepted for p values < 0.05.

Results

Patient Characteristics

The final cohort meeting entry criteria consisted of 46 patients with UC. We initially reviewed 49 patient records and excluded 3 patients who were lost to follow-up without any post-surgical documentation regarding the status of their pouch. Thirty-nine patients (84.8%) had a Paris Classification [13] of E4 (pancolitis) and 35 patients (77.6%) had a history of acute severe UC (Pediatric UC Activity Index ≥ 65) (Table 1). Eighteen patients (39.1%) had ileal inflammation documented via cross-sectional imaging (magnetic resonance imaging [MRI] or computerized tomography [CT]), endoscopy, or histology prior to colectomy. The mean age of UC diagnosis was 12.7 ± 4.8 years (standard deviation [SD]), and the mean age at colectomy was 14.9 ± 3.5 years. Most patients had a 3-stage procedure (63.0%). Fourteen (30%) were receiving systemic corticosteroids at the time of colectomy. Most patients (60%) failed biologic therapy. The median time from colectomy to stage 2 was 2.9 months [interquartile range (IQR): 2.2–4.6 months], followed by a median time of 2.0 months [IQR: 1.7–3.0 months] from stage 2 to stage 3 (Table 1). Compared with those who underwent a 2-stage procedure, patients who had a 3-stage operation were older, of non-Hispanic ethnicity, had extra-intestinal manifestations, and had lower albumin, weight-for-age and BMI-for-age Z-scores at colectomy (Table 2). Thirteen surgeons performed the surgeries.

Incidence of Chronic or Recurrent Pouchitis—Twenty patients (43.5%) developed chronic or recurrent pouchitis during the 2-year follow-up period; 19 (95%) had endoscopically confirmed diagnosis of pouchitis, while one was classified based on symptoms. Patients who developed chronic or recurrent pouchitis did not differ from those who did not with respect to gender, ethnicity, age at diagnosis, Paris Classification, extra-intestinal manifestations, UC medication use, baseline laboratory tests (hematocrit and

albumin) or anthropometric measurements, number of surgical stages, time between stages, or type of anastomosis (Table 3). The same analyses found no differences in patients with no history of pouchitis compared with those with recurrent or chronic pouchitis. We therefore combined those with no history of pouchitis and those with acute pouchitis to compare with the chronic or recurrent cohort.

Changes in Nutritional Markers Across Surgical Stages—Patients who had a 3-stage procedure showed significant improvements in albumin ($p = 0.002$), hematocrit ($p = 0.002$), and BMI-for-age Z-scores ($p = 0.008$) immediately following Stage 1 (Table 4). However, no subsequent differences in laboratory or anthropometric measures were found between stages 2 to 3 ($p > 0.05$). In patients who underwent a 2-stage surgery, there were no significant changes in albumin ($p = 0.27$) and hematocrit ($p = 0.60$), but improvement in BMI ($p = 0.08$) bordered on significance. After takedown, all patients had a sustained improvement in albumin, BMI-for-age Z-scores, and hematocrit throughout the follow-up period. The proportion of patients with hypoalbuminemia improved from 75 at the time of colectomy to 10% at the end of follow-up ($p = 0.46$). The proportion of patients with anemia improved from 80 at colectomy to 31% at last follow-up ($p = 0.66$).

Changes in Nutritional Markers Based on Incidence of Pouchitis—Among patients who underwent 3-stage surgeries, BMI-for-age declined by 1.1 SDs between colectomy to stage 2 in those who developed chronic or recurrent pouchitis (Table 5). Conversely, those who did not develop chronic or recurrent pouchitis experienced an increase in BMI by 0.8 SDs over this same span. In using matched-pairs within-person testing, the improvement within the no pouchitis group was significant ($p = 0.04$), whereas the worsening BMI among pouchitis patients did not meet significance ($p = 0.24$). Logistic regression analysis was employed to examine the differences on a group level, and neither the change in BMI Z-score ($p = 0.26$) nor the BMI Z-score at stage 2 ($p = 0.14$) was statistically significant.

Improvements in hematocrit and albumin were similar across patients prior to J-pouch creation; median values for hematocrit increased by approximately 5% and median albumin increased by 1.4 g/dL. These increases were significant in the ‘no pouchitis’ group ($p = 0.03$ for albumin and hematocrit) and trended toward significance in the pouchitis group ($p = 0.05$ for albumin and $p = 0.06$ for hematocrit) (Table 5). Comparison across groups using logistic regression yielded no differences in changes in albumin ($p = 0.65$) nor hematocrit ($p = 0.59$).

Discussion

Our study showcased (1) a frequent incidence of post-colectomy pouchitis in pediatric patients with UC, (2) sustained improvement in nutrition independent of operative type or pouchitis incidence, and (3) earlier improvements in BMI-for-age Z-scores in patients who did not develop recurrent or chronic pouchitis following a 3-stage surgery. The cumulative incidence of recurrent or chronic pouchitis in our cohort was 44% within 2-year post-ileostomy takedown. These results are congruent with previous single-center studies [1, 9, 26-29].

To build upon the existing research on pediatric RP-IPAA outcomes, we elucidated the changes in nutritional status during and after the surgical stages. In our cohort, patients who underwent a 3-stage procedure had lower BMI-for-age *Z*-scores, albumin, and hematocrit at colectomy. This is likely indicative of patients with more severe baseline illness being selected for 3-stage operations. However, we found sustained improvement in BMI-for-age *Z*-scores and biochemical markers (albumin and hematocrit), regardless of procedure type and independent of pouchitis outcome. These results were supported by our within-person analyses that also showed sustained improvement. At colectomy, the median laboratory values across our cohort indicated a high prevalence of hypoalbuminemia and anemia. These normalized within 3–6 months following ileostomy takedown, and the effect was durable for up to 2 years of follow-up.

The etiology of these initial laboratory abnormalities in this patient population is likely multi-factorial, including malnutrition, losses across an inflamed colonic mucosa and suppression due to systemic inflammation [17, 30, 31]. We hypothesized that resection of the diseased colon reduced the inflammatory burden, improved mucosal albumin leak and gastrointestinal bleeding, and therefore resulted in rapid improvements prior to stage 2. Moreover, given the parallel improvements in BMI-for-age *Z*-scores for up to 2 years of follow-up, we posit that an overall superior nutrition status contributes to sustained laboratory improvements. Previous studies support post-colectomy growth changes, showing improved height velocity in pre-adolescent patients, and better catch-up growth in those with lower lifetime corticosteroid exposure [11, 32]. Patients with active UC have higher resting energy requirements, and the sustained improvements noted in our study were possibly due to a normalization of metabolic demand from decreased inflammatory burden, coupled with better appetites secondary to improved symptoms [33, 34].

In our cohort, the risk of developing chronic or recurrent pouchitis was not associated with patient demographics, disease history, nutritional or growth markers at time of colectomy, or surgical variables such as operation type, time between stages and type of ileoanal anastomosis. Furthermore, our analysis of multiple components of disease history including age at UC diagnosis, disease extent, extra-intestinal manifestations, history of severe disease, and biologic use showed no correlation with the risk for chronic or recurrent pouchitis. Our results corroborated those of previous reports which showed no relationship with disease characteristics (age at UC diagnosis, age at colectomy, UC medication use, extent of colitis, extra-intestinal manifestations, ileitis) or surgical variables (operative stages, anastomosis type) [6, 8]. Conversely, other studies indicated that extra-intestinal manifestations, younger age at UC diagnosis, ileitis, 3-stage RP-IPAA, and extensive colitis were potential pouchitis risk factors [9, 35, 36]. The current data on pouchitis-associated risk factors are equivocal, and the paucity of pediatric literature limits the ability to risk-stratify patients. Ultimately, larger studies or meta-analyses are required to develop a more comprehensive understanding of risk profiles.

We investigated the association of growth measurements and the incidence of pouchitis. Similar to Dharmaraj et al., we found no relationship with BMI-for-age *Z*-scores at the time of colectomy [6]. However, among patients who underwent 3-stage procedures, we found that BMI-for-age *Z*-scores improved (+ 0.8 SD) prior to J-pouch construction in those who

did not develop pouchitis. In contrast, there was a sizable downtrend (− 1.1 SD) in those who did develop pouchitis. The lack of statistical significance is likely due to sample size, but the drastic differences in growth trajectory may hold clinical relevance. As elevated proinflammatory cytokines secreted from inflamed mucosa are thought to play a mechanistic role in the development of pouchitis [37], we hypothesized that this proinflammatory state altered metabolic demand to slow growth trajectory. Given the retrospective study design and sample size limitations, we were unable to establish causality, but rather reference these divergent BMI changes as a potential focus of future research. Patients who have negative growth trajectories following colectomy may be at increased risk for pouchitis; however, further research is required to conclusively determine the prognostic value and the clinical impact of this potential modifiable risk factor.

Similar to previous reports in pediatric patients with UC-related pouchitis, our study was limited by sample size. Additionally, most patients underwent 3-stage procedures, which limited statistical power for analysis on those who had a 2-stage surgery. While we adjusted for operation type and used within-person analyses to address baseline differences, there are possible sources of residual bias in combining these procedures. However, given sustained improvement across the cohorts, it is unlikely to significantly affect our results. Variability in follow-up time points led to the need for larger post-surgical time windows to collect the follow-up data. Although 95% of our chronic or recurrent pouchitis cases were diagnosed endoscopically, we did not use a Pouch Disease Activity Index (PDAI) to standardize the diagnosis across clinicians [38]. We accept that our nutritional evaluation was not comprehensive, and that the biomarker levels may be influenced by alternative etiologies. Albumin could be lower due to inflammation and intestinal losses [30, 31]. Similarly, hematocrit may also be lower due to mucosal bleeding and must be interpreted in the appropriate clinical context. Given the retrospective nature of our analysis, we opted to use biomarkers routinely collected as part of clinical care since we were unable to trend additional growth parameters such as mid-upper arm circumference or serum nutrition markers [39, 40].

Larger pediatric studies are needed to further clarify the risk factors and ultimately guide evidence-based interventions to improve the outcomes following RP-IPAA. Our data suggest that nutrition may serve as a possible modifiable prognostic factor, but prospective studies are needed to evaluate the effect of pre- and post-colectomy nutritional support on pouchitis development in children. Many of the current pediatric reports on pouchitis and quality of life post-IPAA are retrospective single-center experiences. The creation of multi-center cohorts or the inclusion of post-colectomy patients into existing registries such as ImproveCareNow (ICN) will be critical to developing evidence-based approaches to risk-stratification, prevention, and treatment. A prospective registry will also promote future studies evaluating the impact of early interventions and provide evidence as to the optimal time to create a surgical pouch to reduce complications and improve pouch function.

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Table 1

Baseline characteristics of pediatric patients with ulcerative colitis undergoing colectomy

Number of patients	46
Female	27 (58.7%)
Ethnicity (non-Hispanic)	34 (73.9%)
Age at diagnosis (mean ± SD)*	12.2 ± 3.8 years
Paris classification	
Pancolitis (E4)	39 (84.8%)
Severity (S1)	35 (76.1%)
Extra-intestinal manifestations	24 (52.1%)
Previous biologic use	28 (60.9%)
Ileitis$^{\Delta}$	18 (39.1%)
Age at colectomy (mean ± SD)	14.9 ± 3.5 years
Number of surgical stages	
2-stage	17 (37.0%)
3-stage	29 (63.0%)
Steroids at colectomy	14 (30%)
3-stage surgery	
Time from colectomy to stage 2 (median [IQR])$^{\bigcirc}$	2.9 [2.2–4.6] months
Time from stage 2 to stage 3 (median [IQR])	2.0 [1.7–3.0] months
2-stage surgery	
Time between stages (median [IQR])	2.3 [2.2–2.9] months

*SD standard deviation

$^{\Delta}$Ileitis seen on cross-sectional imaging, endoscopy, or histology

$^{\bigcirc}$*IQR* interquartile range

Table 2

Comparison of baseline characteristics of pediatric patients with Ulcerative colitis undergoing 2-stage versus 3-stage restorative proctocolectomy and ileal pouch anal anastomosis

	2-stage surgery	3-stage surgery	*p* value
Number of patients	17	29	–
Female	9 (53.0%)	18 (62.1%)	0.54
Ethnicity (non-Hispanic)	16 (94.1%)	18 (62.1%)	0.02
Age (mean ± SD)	10.2 ± 3.5 years	14.1 ± 2.9 years	< 0.01
Paris classification			
Pancolitis (E4)	12 (70.5%)	27 (93.1%)	0.08
Severity (S1)	12 (70.5%)	23 (79.3%)	0.73
Extra-intestinal manifestations	4 (23.5%)	20 (58.6%)	< 0.01
Previous biologic use	9 (53.0%)	19 (70.4%)	0.53
Ileitis	4 (23.5%)	14 (48.3%)	0.12
Age at colectomy (mean ± SD)	14.9 ± 3.6 years	15.3 ± 3.3 years	0.86
Steroids at colectomy	4 (23.5%)	10 (34.5%)	0.52
Labs at colectomy (mean ± SD)			
Hematocrit (%)	33.5 ± 3.7	31.2 ± 5.0	0.11
Albumin (g/dL)	3.5 ± 0.6	2.7 ± 0.5	< 0.01
Colectomy anthropometrics			
Weight-for-age *Z*-score	0.1 ± 1.3	− 0.9 ± 1.3	0.03
BMI-for-age *Z*-score	0.1 ± 1.1	− 0.9 ± 1.3	0.02

Table 3

Associations of characteristics of pediatric patients with ulcerative colitis and risk of chronic or recurrent pouchitis

	Recurrent or chronic pouchitis	No recurrent or chronic pouchitis	*p* value
Number of patients	20 (43.5%)	26 (56.5%)	–
Female	15 (75.0%)	12 (46.1%)	0.08
Ethnicity (non-Hispanic)	16 (80.0%)	18 (69.2%)	0.51
Age at diagnosis (mean ± SD) *	12.7 ± 4.8 years	12.6 ± 2.6 years	0.67
Age at colectomy (mean ± SD)	15.3 ± 3.9 years	15.0 ± 2.9 years	0.36
Paris classification			
Pancolitis (E4)	16 (80.0%)	23 (88.5%)	0.23
Severity (S1)	17 (85.0%)	18 (69.2%)	0.47
Extra-intestinal manifestations	12 (60.0%)	12 (46.2%)	0.39
Ileitis Δ	7 (35.0%)	11 (42.3%)	0.76
Previous biologic use	10 (50.0%)	18 (69.2%)	0.23
Systemic steroids at the time of colectomy	4 (20.0%)	10 (38.5%)	0.21
Labs at colectomy (mean ± SD)			
Hematocrit (%)	31.5 ± 4.8	32.5 ± 4.5	0.58
Albumin (g/dL)	2.8 ± 0.2	2.9 ± 0.1	0.75
Colectomy anthropometrics			
Weight-for-age *Z*-score	− 0.24	− 0.74	0.14
BMI-for-age *Z*-score ◆	− 0.45	− 0.64	0.58
Number of surgical stages			
2-stage	10 (50.0%)	7 (26.9%)	Reference
3-stage	10 (50.0%)	19 (73.1%)	0.14
Time from colectomy to stage 2 (median [IQR]) ○	2.8 [2.2–9.4] months	2.9 [2.3–4.6] months	0.62
Time from stage 2 to stage 3 (median [IQR])	2.0 [1.6–6.4] months	1.9 [1.8–2.8] months	0.91
Stapled anastomosis	16 (80%)	21 (81%)	0.95

Compares patients who developed recurrent or chronic pouchitis versus those who did not

* *SD* standard deviation

Δ Ileitis seen on cross-sectional imaging, endoscopy, or histology

◆ *BMI* body mass index

○ *IQR* interquartile range

Table 4

Nutrition markers at each surgical stage and post-ileostomy takedown

	Albumin (g/dL)	Hematocrit (%)	BMI-for-age *Z*-scores
Stage 1[a]	2.6 [2.3–3.4]	32.1 [29.4–35.1]	− 0.6 [− 1.6 to 0.4]
Stage 2[b]	4.0 [3.9–4.5] *	38.0 [32.4–40.9] *	− 0.4 [− 1.2 to 0.9] *
Takedown (Stage 3)[c]	3.9 [3.3–4.1]	38.2 [34.3–39.7]	− 0.5 [− 1.2 to 0.6]
3–6 months post-takedown	4.2 [3.8–4.5]	38.7 [35.2–40.1]	− 0.4 [− 1.3to 0.6]
1–2 years post-takedown	4.2 [4.0–4.5] ◆	38.6 [35.1–42.0]	0.0 [− 0.8 to 0.8]

Median [interquartile range] values for albumin, hematocrit, and body mass index (BMI)-for-age *Z*-scores across the surgical stages and follow-up period

* Statistically significant ($p < 0.05$) improvement compared to Stage 1

◆ Statistically significant ($p < 0.05$) improvement compared to takedown (stage 3)

[a] Stage 1: For a 2-stage surgery, Stage 1 is a proctocolectomy with creation of the loop ileostomy with J-pouch creation. For a 3-stage surgery, Stage 1 entails a sub-total colectomy and end ileostomy

[b] Stage 2: Completion proctectomy with ileal pouch and diverting loop ileostomy; solely for those who undergo a 3-stage procedure

[c] Takedown (Stage 3): Ileostomy takedown in both 2-stage and 3-stage surgeries

Table 5

Nutrition markers at each surgical stage and post-ileostomy takedown in patients with and without chronic or recurrent pouchitis

	Albumin (g/dL)		Hematocrit (%)		BMI-for-age *Z*-score	
	No pouchitis	**Pouchitis**	**No pouchitis**	**Pouchitis**	**No pouchitis**	**Pouchitis**
Stage 1[a]	2.8 [2.3–3.6]	2.6 [2.4–3.4]	32.7 [29.4–35.0]	31.4 [30.0–35.3]	− 0.7 [− 1.2 to 0.2]	0.0 [− 1.7 to 0.6]
Stage 2[b]	4.2 [4.0–4.6] *	4.0 [3.8–4.0]	38.3 [31.8–40.9] *	36.5 [34.0–40.1]	0.1 [− 0.9–0.9] *	− 1.1 [− 1.5 to 0.5]
Takedown (Stage 3)[c]	3.8 [3.1–4.4]	3.8 [3.3–4.1]	36.1 [34.2–39.6]	38.2 [35.1–38.9]	0.4 [− 1.2 to 0.7]	− 0.6 [− 1.3 to 0.4]
3–6 months post-takedown	4.3 [4.2–4.6]	3.8 [3.3–4.1]	39.5 [37.8–42.5]	36.4 [34.6–39.5]	0.5 [− 1.3 to 0.5]	0.2 [− 1.8 to 0.6]
1–2 years post-takedown	4.3 [4.1–4.5]	4.2 [3.6–4.5]	38.9 [38.0–43.0]	37.4 [34.9–41.8]	0.1 [− 0.7 to 1.0]	0.2 [− 0.8 to 0.8]

Median [interquartile range] values for patients with recurrent or chronic pouchitis (“pouchitis” columns) versus those without (“no pouchitis” columns)

* Statistically significant ($p < 0.05$) improvement compared to baseline (colectomy)

[a] Stage 1: For a 2-stage surgery, Stage 1 is a proctocolectomy with creation of the loop ileostomy with J-pouch creation. For a 3-stage surgery, Stage 1 entails a sub-total colectomy and end ileostomy

[b] Stage 2: Completion proctectomy with ileal pouch and diverting loop ileostomy; solely for those who undergo a 3-stage procedure

[c] Takedown (Stage 3): Ileostomy takedown in both 2-stage and 3-stage surgeries