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Equivalency of short-term perioperative outcomes after open, laparoscopic, and robotic ileal pouch anal anastomosis. Does procedure complexity override operative approach?

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ABSTRACT

Background: Ileal pouch anal anastomosis is the treatment of choice for patients with chronic ulcerative colitis and familial adenomatous polyposis undergoing a proctocolectomy and desiring bowel continuity. It is a technically complex operation associated with significant morbidity and may be performed by an open, laparoscopic, or robotic approach. However, there is a paucity of data regarding the comparative perioperative outcomes between these 3 techniques outside of institutional studies.
Methods: The NSQIP targeted proctectomy data set was used to identify patients who underwent open, laparoscopic, and robotic ileal pouch anal anastomosis between 2016 and 2019. Thirty-day outcomes between different surgical approaches were compared using univariate and multivariable analysis.
Results: During the study period, 1,067 open, 971 laparoscopic, and 341 robotic ileal pouch anal anastomosis were performed. The most frequent indications were inflammatory bowel disease (64%), malignancy (18%), and familial adenomatous polyposis (7%). Mean age of the cohort was 43 ± 15 years with 43% female and 76% with body mass index ≤30 kg/m^2. Overall morbidity was 26.8% for the entire cohort with 4% anastomotic leak, 6% reoperation, 21% ileus, and 21% readmission rate. After adjusting for available confounders, operative approach was not associated with better short-term outcomes, including length of stay, overall morbidity, anastomotic leak, reoperation, incidence of ileus, and 30-day readmissions.
Conclusion: Ileal pouch anal anastomosis continues to be associated with significant postoperative morbidity regardless of operative approach. Patient-related advantages in terms of perioperative outcomes for laparoscopic and robotic platforms compared to open surgery are less pronounced in complex operations such as ileal pouch anal anastomosis.

INTRODUCTION

Due to its ability to avoid a permanent stoma, a proctocolectomy with an ileal pouch anal anastomosis (IPAA) is considered the ideal surgical treatment for patients desiring intestinal continuity with either chronic ulcerative colitis (CUC), which is medically refractory or has dysplasia/malignancy, or familial adenomatous polyposis (FAP). When this technique was initially described in 1978 by Sir Alan Parks and John Nicholls, it was performed through a midline laparotomy [1]. However, with the evolution of laparoscopy in the 1990s and its advantages in terms of patient-related perioperative outcomes, IPAAs were also performed laparoscopically [2]. However, the widespread uptake of minimally invasive IPAA was limited by the complexity of the operation, its relatively long and steep learning curve, and arguable benefits in short-term perioperative outcomes. In 2 separate systematic reviews [3,4] of studies comparing open versus laparoscopic IPAA, despite the perceived long-term benefits such as decreased incidence of adhesive small bowel obstruction and improved cosmesis, no significant differences in perioperative morbidity and mortality were observed.

Since its introduction in the 2000s, the use of robotic platforms has substantially expanded in general surgery including its application in

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colorectal surgery [5]. The wristed instruments with 7 degrees of articulation, tremor reduction, and 3-dimensional high-definition view were considered a significant advance over laparoscopy particularly when operating in the pelvis. As a result, IPAA began being performed using the robotic platform because the technology was considered to overcome some of the limitations of laparoscopy and had a shorter learning curve, while potentially preserving the benefits of minimally invasive surgery [6–8]. Although initial reports and institutional studies found this approach to be safe and feasible [9–11], comparative studies were unable to detect a substantial advantage of robotic surgery and observed comparable rates of overall complications, anastomotic leaks, and return to operating room been between open, laparoscopic, and robotic approaches [12]. However, all of these studies were institutional series with small sample sizes. Corresponding findings have also been seen in other complex operations such as major hepatic resections [13,14], pancreatoduodenectomies [15], and esophagectomies, [16] where minimally invasive approaches, including robotic and laparoscopic surgery, were found to have similar perioperative outcomes compared to traditional open surgery.

We therefore hypothesized that among patients undergoing an IPAA, the perioperative outcomes would be equivalent for all 3 approaches as minimally invasive techniques cannot overcome the impact of the surgical complexity of an IPAA on perioperative morbidity. Leveraging the advantages of the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) targeted proctectomy database that uniquely discriminates between open, laparoscopic, and robotic IPAA and collects standardized perioperative 30-day morbidity, we compared the clinical outcomes of patients undergoing IPAA by these 3 different approaches.

PATIENTS AND METHODS

Data Source. The ACS-NSQIP prospectively collects approximately 240 Health Insurance Portability and Accountability Act–compliant variables and surgical outcomes using standardized and validated definitions. The proctectomy-targeted participant use data file (PUF) further includes unique proctectomy specific pre- and postoperative variables including operative approach (open versus laparoscopic versus robotic). Patient data from the proctectomy targeted PUF were linked to the general PUF for demographic and general operative and postoperative data, and only patients with the data in both databases were analyzed.

Operative Approach. Patients undergoing an open proctocolectomy with IPAA (current procedural terminology [CPT] codes 44157 and 44158), laparoscopic proctocolectomy with IPAA (CPT code 44211), or a completion proctectomy with IPAA (CPT code 45113) between 2016 and 2019 were identified from the PUF files. Based on indication, patients were categorized into 4 main diagnostic groups, namely, inflammatory bowel disease, familial polyposis, malignancy, and others based on the *International Classification of Diseases* (*ICD*)-*9* and *ICD-10* codes. Patients were analyzed after being divided into 3 groups based on initial operative approach, which was identified from the surgeon's operative report and is recorded in the proctectomy-targeted PUF. The *open* group included cases coded as open (planned); the *laparoscopic* group as cases coded as laparoscopic, laparoscopic assisted, or laparoscopic converted to open; and the *robotic* group as cases coded as robotic, robotic assisted, or robotic converted to open. All procedures coded as being performed by endoscopic surgery, natural orifice transluminal surgery, single-incision laparoscopic surgery, other minimally invasive surgical approaches, or hybrid approaches were excluded. Additionally, cases classified as emergent were excluded.

Covariates and Outcomes. Data collected included patient demographics, comorbidities, diagnoses, and 30-day perioperative complications including anastomotic leak (AL), postoperative ileus, length of stay (LOS), readmissions, reoperations, and mortality. Complications were categorized as follows: minor complications or Clavien–Dindo 1–2 complications, defined as superficial surgical site infections (SSI), wound disruption, *C difficile*, pneumonia, urinary tract infection, acute renal failure, and deep vein thrombosis, and major complications or Clavien–Dindo grade ≥ 3 complications, defined as organ space or deep SSI, wound dehiscence, septic shock, sepsis, reintubation, ventilator > 48 hours, pulmonary embolism, cerebrovascular accident, myocardial infarction, cardiac arrest, and progressive renal insufficiency.

Statistical Analyses. The χ^2 test was used to compare categorical 23variables, and the Wilcoxon rank-sum test was used to compare non-normally distributed continuous variables. All tests were 2-sided. Our primary outcomes were overall 30-day morbidity, grade 1–2 complications, grade ≥ 3 complications, anastomotic leak, reoperation, ileus, and readmissions. Univariate analysis was performed against our primary outcomes, and variables significant at $P < .1$ were selected for inclusion in our multivariate model. All data were analyzed using SAS version 9.4 (SAS Institute, Cary, NC) 9.3.5. This study was exempt from review by the University of Iowa Institutional Review Board due to the use of deidentified data and the retrospective nature of the study.

RESULTS

Patient Characteristics. During the study period, 1,067 patients had an open, 971 a laparoscopic, and 341 a robotic IPAA. There were no significant differences in the mean age or proportion of patients with a body mass index (BMI) greater than 30 between the 3 groups, although there were a higher proportion of males undergoing a robotic approach (Table 1). There were no significant differences in the ASA scores or preoperative comorbidities between the 3 groups other than a higher proportion of patients on steroids/immunosuppressants in the laparoscopic group. The most frequent indication for surgery was inflammatory bowel disease (IBD, 64%) followed by malignancy (18%), other indications (12%), and FAP (7%). The proportion of patients undergoing an IPAA for IBD was similar between the 3 approaches; however, patients undergoing an open IPAA were less likely to have FAP and more likely to undergo it for other indications as compared to the other 2 groups. A greater proportion of patients underwent a completion proctectomy with IPAA by an open approach (75%) compared to laparoscopic (17%) and robotic (7%) approaches ($P < .001$), whereas most proctocolectomies and IPAA were performed by a laparoscopic and robotic approach (53% and 18%, respectively). Operative times were greater in the robotic and laparoscopic groups (mean times 353 [SD $\pm$133] and 298 [SD $\pm$111] minutes, respectively) compared to the open group (mean time 240 [SD $\pm$97] minutes).

Patient Outcomes. The overall postoperative 30-day morbidity for the cohort was 26.8%, with 12.3% grade 1–2 complications and 14.5% grade ≥ 3 complications. Grade 1–2 complications were significantly different between the 3 approaches primarily due to the higher incidence of SSI in the open group as the incidence of remaining complications was similar. However, the incidence of grade ≥ 3 complications was not significantly different between the groups (Table 2). The AL rate was 4%, incidence of ileus was approximately 21%, and 30-day readmission rate was 21%, which were all similar between the groups. There were 6 mortalities in the whole cohort.

In the adjusted analyses, higher BMI and use of steroid/immunosuppressants were associated with higher incidence of overall and grade ≥ 3 complications. Operative approach was not associated with increased incidence of overall complications, grade ≥ 3 complications, ileus, readmissions (Tables 3–6), and grade 1–2 complications and AL (Supplementary Tables 1 and 2).

Discussion

In this contemporary analysis using the NSQIP targeted proctectomy database, we observed that a significant proportion of patients

Table 1
Clinical characteristics of patients undergoing an ileal pouch-anal anastomosis by surgical approach in NSQIP targeted proctectomy database (2016–2019)

Characteristics	*Approach*				P *value*
	All approaches	*Open*	*Laparoscopy*	*Robotic*	
	N = *2,379 (%)*	n = *1,067 (%)*	n = *971 (%)*	n = *341 (%)*	
Age, mean (±SD)	43.0 (15.3)	43.4 (15.3)	42.9 (15.4)	42.2 (15.1)	.424
Sex, male	1,348 (56.7)	601 (56.3)	531 (54.7)	216 (63.3)	*.02*
Race					*.004*
Black	102 (4.3)	52 (4.9)	27 (2.8)	23 (6.7)	
Other	425 (17.9)	207 (19.4)	167 (17.2)	51 (15.0)	
White	1,852 (77.9)	808 (75.7)	777 (80.0)	267 (78.3)	
BMI					.161
>40	46 (1.9)	19 (1.8)	18 (1.9)	9 (2.7)	
30–40	504 (21.2)	210 (19.9)	207 (21.4)	87 (25.7)	
<30	1,813 (76.2)	828 (78.3)	742 (76.7)	243 (71.7)	
ASA category ≥3	924 (38.8)	419 (39.3)	365 (37.6)	140 (41.1)	.493
Smoking history	231 (9.7)	95 (8.9)	95 (9.8)	41 (12.0)	.237
Diabetes	133 (5.6)	61 (5.7)	48 (4.9)	24 (7.0)	.34
History of COPD	17 (0.7)	8 (0.7)	7 (0.7)	2 (0.6)	.952
History of ascites	5 (0.2)	5 (0.5)	0 (0.0)	0 (0.0)	.046
Hypertension medication use	387 (16.3)	170 (15.9)	155 (16.0)	62 (18.2)	.585
Steroid/immunosuppressant	532 (22.4)	168 (15.7)	299 (30.8)	65 (19.1)	*<.001*
>10% Weight loss	84 (3.5)	39 (3.7)	34 (3.5)	11 (3.2)	.931
Bleeding disorder	39 (1.6)	21 (2.0)	14 (1.4)	4 (1.2)	.494
Indication					*<.001*
Familial adenomatous polyposis	161 (6.8)	36 (3.4)	84 (8.7)	41 (12.0)	
Inflammatory bowel disease	1,511 (63.5)	685 (64.2)	621 (64.0)	205 (60.1)	
Other	284 (11.9)	183 (17.2)	80 (8.2)	21 (6.2)	
Malignant/benign tumor	423 (17.8)	163 (15.3)	186 (19.2)	74 (21.7)	
Major secondary code	124 (5.2)	65 (6.1)	39 (4.0)	20 (5.9)	.092
Operative time, mean (±SD)	280.0 (115.7)	240.4 (96.7)	297.8 (111.1)	353.6 (133.6)	*<.001*
Length of stay, mean (±SD)	6.9 (4.9)	7.1 (5.1)	6.7 (4.7)	6.9 (4.6)	.199
Extent of procedure					
Proctectomy	850 (35.7)	644 (60.4)	147 (15.1)	59 (17.3)	*<.001*
Proctocolectomy	1,538 (64.7)	432 (39.6)	824 (84.9)	282 (82.7)	

Italicized characteristics meet statistical significance.
COPD, chronic obstructive pulmonary disease.

undergoing an IPAA experienced postoperative complications. This included overall minor and major morbidity as well as specific complications such as SSI, delay in return of gastrointestinal function/ileus, anastomotic leak, and readmission within 30 days. However, despite the risk of selection bias, these outcomes were comparable among the open, laparoscopic, and robotic approaches even after adjusting for available patient and disease confounders. We also identified well-established risk factors such as higher BMI and use of steroids/immunosuppressants to be associated with overall and major postoperative morbidity.

Although representing the ideal procedure for patients undergoing a proctocolectomy and desiring intestinal continuity, IPAA remains a complex operation that is technically difficult and inherently morbid. Furthermore, even though it may be performed in relatively young individuals, a significant proportion of patients may be immunocompromised and/or malnourished due to both the disease and as consequence of medical treatment, which can adversely impact perioperative outcomes. The reported incidence and profile of early postoperative complications after an open and laparoscopic IPAA have been well documented and approaches ~30%–40% even in experienced and high-volume centers [4,17,18]. The data regarding outcomes after robotic IPAA are mainly limited to institutional case series with even fewer studies comparing the different approaches [12]. The cumulative rate for overall complications in comparative studies for laparoscopic and robotic IPAA has been reported to be 34% and 44%, respectively [12]. In a systematic review of 9 studies in which 640 patients were analyzed (170 open, 174 laparoscopic, and 286 robotic), there were similar rates of overall complications, anastomotic leaks, and return to operating room among the 3 groups [12]. Our findings of significant morbidity after IPAA performed by open and minimally invasive techniques are therefore in line with previously published data evaluating short-term operative outcomes.

The patient-related benefits of laparoscopy in terms of earlier return in bowel function, shorter length of stay, and fewer postoperative complications due to less surgical trauma are well established. Patients undergoing various advanced laparoscopic procedures such as paraesophageal hernia repair [19], Roux-en-Y gastric bypass [20,21], and segmental colectomy [22] have consistently been found to have measurably better perioperative outcomes compared to patients undergoing the same operation by an open approach. These corresponding findings have also been confirmed when these procedures were performed on a robotic platform [20,23,24]. In our analysis, although the incidence of morbidity was high and comparable with the published literature, we were unable to identify a significant benefit of laparoscopic or robotic approaches over open surgery. These findings are however not unique to IPAA as there are other similar complex procedures such as esophagectomy [4,25], pancreatoduodenectomy [4,26], and hepatectomy [13] where laparoscopic and robotic approaches have not demonstrated to have the same clinically appreciable difference in perioperative outcomes. In a meta-analysis of 41 studies [15] (38 were observational) including 56,440 patients (85.7% open, 9.8% laparoscopic, and 4.5% robotic) undergoing a pancreatoduodenectomy, it was observed that all 3 approaches were equally safe with similar postoperative mortality, grade B/C postoperative fistula rate, and severe postoperative complications (Clavien–Dindo 3–4). However, hospital length of stay, readmission, and overall complication rate were lower in the laparoscopic and robotic group as compared to the open group [15]. In a systematic review [25] of 21 studies (2 randomized trials, 11 propensity-matched studies, and 8 unmatched studies), 9,355 patients undergoing esophagectomy by various approaches were analyzed. Robotic-assisted minimally invasive esophagectomy had similar perioperative outcomes including anastomotic leak and total complications compared to video-assisted and open esophagectomy, except for pulmonary complications which were lower [25].

Table 2
Univariate comparison of 30-day perioperative outcomes based on surgical approach

Characteristics	Approach				P value
	All approaches	Open	Laparoscopy	Robotic	
	N = 2,379 (%)	n = 1,067 (%)	n = 971 (%)	n = 341 (%)	
Grade 1–2	293 (12.3)	154 (14.4)	100 (10.3)	39 (11.4)	*.016*
Deep vein thrombosis	44 (1.8)	14 (1.3)	26 (2.7)	4 (1.2)	*.044*
Wound disruption	11 (0.5)	6 (0.6)	2 (0.2)	3 (0.9)	.233
Renal failure	9 (0.4)	4 (0.4)	4 (0.4)	1 (0.3)	.954
Clostridium difficile infection	4 (0.2)	2 (0.2)	1 (0.1)	1 (0.3)	.746
Sepsis	82 (3.5)	44 (4.1)	25 (2.6)	13 (3.8)	.148
Urinary tract infection	69 (2.9)	34 (3.2)	23 (2.4)	12 (3.5)	.417
Pneumonia	24 (1.0)	9 (0.8)	11 (1.1)	4 (1.2)	.766
Superficial SSI	99 (4.2)	72 (6.7)	20 (2.1)	7 (2.1)	*<.001*
Grade ≥ 3	346 (14.5)	158 (14.8)	134 (13.8)	54 (15.8)	.622
Deep wound infection	26 (1.0)	18 (1.7)	5 (0.5)	3 (0.9)	.036
Organ space SSI	198 (8.3)	90 (8.4)	80 (8.2)	28 (8.2)	.984
Unplanned intubation	10 (0.4)	2 (0.2)	6 (0.6)	2 (0.6)	.285
Pulmonary embolism	7 (0.3)	5 (0.5)	2 (0.2)	0 (0.0)	.306
On ventilator >48 h	10 (0.4)	2 (0.2)	6 (0.6)	2 (0.6)	.285
Progressive renal insufficiency	34 (1.4)	15 (1.4)	16 (1.6)	3 (0.9)	.587
Stroke/CVA	1 (0.0)	0 (0.0)	1 (0.1)	0 (0.0)	.484
Cardiac arrest	4 (0.2)	1 (0.1)	2 (0.2)	1 (0.3)	.686
Myocardial infarction	4 (0.2)	3 (0.3)	1 (0.1)	0 (0.0)	.442
Septic shock	18 (0.8)	6 (0.6)	10 (1.0)	2 (0.6)	.442
Reoperation	134 (5.6)	53 (5.0)	54 (5.6)	27 (7.9)	.12
Anastomotic leak	98 (4.1)	43 (4.0)	41 (4.2)	14 (4.1)	.976
Ileus	487 (20.5)	219 (20.5)	201 (20.7)	67 (19.6)	.916
Readmission	499 (21.0)	234 (21.9)	199 (20.5)	66 (19.4)	.532
Death	6 (0.3)	2 (0.2)	3 (0.3)	1 (0.3)	.85

Table 4
Multivariable analysis of factors associated with Grade ≥ 3 complications

Variables		Odds ratio	95% Confidence interval		P value
			Lower bounds	Upper bounds	
Age, continuous		1.003	0.994	1.011	.515
Sex	Female vs male	0.908	0.718	1.149	.423
BMI	*30–40 vs < 30*	1.398	1.067	1.832	*.015*
	>40 vs < 30	2.408	1.224	4.736	*.011*
Race	Black vs white	1.564	0.94	2.6	.085
	Other vs white	1.268	0.941	1.707	.118
ASA	≥3 vs ≤2	1.203	0.939	1.542	.144
Steroids/immunosuppressant	*Yes vs no*	1.415	1.066	1.878	*.016*
Smoking	Yes vs no	1.37	0.95	1.976	.092
Surgical approach	Robotic vs open	1.144	0.794	1.647	.471
	Laparoscopy vs open	0.979	0.735	1.302	.882
Surgical indication	FAP vs tumor	0.728	0.406	1.303	.285
	IBD vs tumor	0.98	0.698	1.376	.905
	Other vs tumor	1.23	0.806	1.876	.337
Extent of surgery	Proctocolectomy vs proctectomy	0.881	0.667	1.165	.375

There are 2 significant confounding factors that need to be considered in this context while interpreting the results from this study. First, even though the groups were well matched in terms of patient demographics and comorbidities, there is the possibility of a selection bias, which could favor better outcomes in the laparoscopic and robotic groups. Second, particularly those patients undergoing robotic surgery could be on the learning curve of the surgeon as this is a relatively new technology, potentially accounting for a certain proportion of the perioperative morbidity. Notwithstanding these factors and their impact on outcomes, it also important to consider the fact that an IPAA is a complex procedure that involves removal of the entire colon (if not already performed), a pelvic dissection to perform a proctectomy, construction of an ileal pouch with an anastomosis to the anal canal, and often a diverting ileostomy. All these individual procedures have significant morbidity associated with them and combined in an immunocompromised and/or malnourished patient can have a cumulative or even additive impact on perioperative outcomes. Therefore, it is possible that in an inherently morbid operation, the positive impact of a laparoscopic or robotic operative approach may not be as clinically evident or even relevant.

Despite the strengths of the database, there are also limitations of this study related to the use of the NSQIP database, including a potential for selection bias in surgical approach. These data come from participating NSQIP sites, which are more likely to be high-volume and/or academic centers, and therefore, any conclusions may not be an accurate representation of national outcomes or have external validity in other settings that have a different volume or expertise profile. Certain variables collected in the database may be miscoded or not available, for instance, the CPT codes do not reliably discriminate whether an ileostomy was performed, or no data are collected on the exact CUC drug regimen and duration of treatment. Finally, the data are limited to 30-day outcomes, so we are unable to assess the effect of important and pertinent long-term complications such as functional outcomes including bowel function and genitourinary dysfunction, incisional hernias, or small

Table 3
Multivariable analysis of factors associated with all complications

Variables		Odds ratio	95% Confidence interval		P Value
			Lower bounds	Upper bounds	
Age, continuous		1.001	0.995	1.007	.867
Sex	Female vs male	0.972	0.822	1.15	.744
BMI	30–40 vs <30	1.175	0.958	1.44	.121
	>40 vs < 30	1.91	1.046	3.488	*.035*
Race	Black vs white	1.128	0.748	1.701	.565
	Other vs white	1.241	0.996	1.546	.055
ASA	≥3 vs ≤2	1.133	0.947	1.357	.172
Steroids/immunosuppressant	*Yes vs no*	1.309	1.06	1.617	*.012*
Smoking	Yes vs no	1.311	0.991	1.734	.058
Surgical approach	Robotic vs open	0.876	0.669	1.147	.336
	Laparoscopy vs open	0.866	0.707	1.062	.167
Surgical indication	FAP vs tumor	0.784	0.528	1.164	.227
	IBD vs tumor	0.905	0.707	1.157	.426
	Other vs tumor	1.047	0.763	1.435	.777
Extent of surgery	Proctocolectomy vs proctectomy	0.953	0.779	1.166	.641

Table 5
Multivariable analysis of factors associated with higher readmission rates

Variables		Odds ratio	95% Confidence interval		P value
			Lower bounds	Upper bounds	
Age, continuous		0.999	0.992	1.006	.822
Sex	Female vs male	1.208	0.987	1.478	.066
BMI	30–40 vs <30	0.975	0.76	1.25	.840
	>40 vs <30	1.165	0.576	2.354	.671
Race	Black vs white	1.334	0.841	2.116	.221
	Other vs white	0.743	0.557	0.99	*.043*
ASA	≥3 vs ≤2	1.147	0.924	1.425	.213
Steroids/immunosuppressant	*Yes vs no*	1.326	1.036	1.697	*.025*
Smoking	Yes vs no	1.234	0.882	1.724	.220
Surgical approach	Robotic vs open	0.856	0.615	1.191	.356
	Laparoscopy vs open	0.913	0.714	1.168	.470
Surgical indication	FAP vs tumor	0.899	0.547	1.478	.675
	IBD vs tumor	1.121	0.827	1.52	.460
	Other vs tumor	0.75	0.498	1.131	.170
Extent of surgery	Proctocolectomy vs proctectomy	0.894	0.7	1.14	.365

Table 6
Multivariable analysis of factors associated with post-operative ileus

Variables		*Odds ratio*	*95% Confidence interval*		*P value*
			Lower bounds	*Upper bounds*	
Age, continuous		1.004	0.997	1.011	.261
Sex	*Female vs male*	0.701	0.569	0.863	*.001*
BMI	30–40 vs <30	1.177	0.923	1.502	.189
	>40 vs <30	1.632	0.837	3.182	.151
Race	Black vs white	0.805	0.469	1.381	.431
	Other vs white	1.24	0.958	1.604	.102
ASA	≥3 vs ≤2	0.929	0.745	1.157	.510
Steroids	Yes vs no	1.266	0.981	1.633	.070
Smoking	Yes vs no	1.122	0.804	1.565	.499
Surgical approach	Robotic vs open	0.927	0.666	1.288	.650
	Laparoscopy vs open	1.002	0.783	1.282	.990
Surgical indication	FAP vs tumor	0.924	0.584	1.461	.734
	IBD vs tumor	0.747	0.559	0.998	*.049*
	Other vs tumor	0.832	0.571	1.214	.340
Extent of surgery	Proctocolectomy vs proctectomy	0.947	0.741	1.211	.665

bowel obstructions secondary to adhesions, particularly since these outcomes are relevant in this population as they are young and have a normal expected life span.

In conclusion, although patients undergoing an IPAA are at risk for significant perioperative morbidity, minimally invasive approaches such as laparoscopy and robotics do not appear to significantly mitigate these outcomes. Like other complex surgical procedures, IPAA remains a technically challenging operation with an inherent morbidity that may not be easily modifiable by operative approach.

Author Contribution

Dorcas Opoku: Study conception and design, formal analysis, data interpretation, and drafting of the manuscript. Alexander Hart, MPH: Data acquisition, formal analysis, and data interpretation. Dakota T. Thompson, MD: Data acquisition, formal analysis, and data interpretation. Catherine G. Tran, MD: Formal analysis, data interpretation, and drafting of the manuscript. Mohammed O. Suraju, MD: Formal analysis, data interpretation, and drafting of the manuscript. Jeremy Chang, MD: Data acquisition, formal analysis, and data interpretation. Sonja Boatman, MD: Formal analysis, data interpretation, and drafting of the manuscript. Alexander Troester, MD: Formal analysis, data interpretation, and drafting of the manuscript. Paolo Goffredo, MD: Study conception and design, critical revision, and supervision. Imran Hassan, MD: Study conception and design, critical revision, and supervision.

Conflict of Interest

None.

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Ethical Approval

This study was exempt from review by the Uni-versity of Iowa Institutional Review Board due to the use of deidentified data and the retrospective nature of the study.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.sopen.2022.05.008.

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