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Laparoscopic ileal pouch-anal anastomosis reduces the risk of surgical site infections: An ACS-NSQIP study

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A R T I C L E I N F O

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A B S T R A C T

Introduction: Previous literature related to postoperative outcomes after laparoscopic vs. open ileal pouch-anal anastomosis (IPAA) is primarily based on small numbers of patients from single institutions. The aim of this study is to evaluate these outcomes in a large number of patients using propensity score matching (PSM).

Material and Methods: The ACS-NSQIP Program data files (2016-2019) were reviewed to identify patients who underwent an IPAA creation. The impact of surgical approach on operative and postoperative outcomes were evaluated. 1:1 propensity score matching (PSM) on all patient characteristics was used to obtain matched groups. Fisher's Exact/Chi-Squared tests were used to compare outcomes between groups. A Bonferroni correction was applied to the outcomes, with a p-value of 0.0031 representing statistical significance.

Results: 1802 patients were identified, with 1001 patients in the laparoscopic group and 801 patients in the open group. PSM yielded 702 patients in each matched group. Median operative time was longer for laparoscopic IPAA (278vs218.5 minutes, $p<0.001$). Laparoscopic IPAA patients were less likely to develop superficial and deep SSIs (3.0% vs 6.6% $p=0.003$). There were no differences in in-hospital mortality (0.4% vs 0.0%, $p=0.3$), anastomotic leak (4.0% vs 3.3%, $p=1.0$), organ-space SSI (6.7% vs 6.0, $p=1.0$), or reoperation (5.7% vs 4.0%, $p=0.2$) between groups. Length of stay was lower after laparoscopic IPAA (5.0 vs 6.0 days, $p=0.004$). There were no differences between groups in other postoperative complications.

Discussion: These data suggest that when matched for other confounding variables, laparoscopic IPAA is associated with reduced length of stay and superficial/deep SSIs when compared to open IPAA. Other surgical complications, including in-hospital mortality and anastomotic leak, are similar.

Conclusion: Given the recovery benefit of the laparoscopic approach and the reduced SSI, laparoscopy should be the method of choice for the majority of patients undergoing IPAA.

Introduction

Total proctocolectomy with ileal pouch-anal anastomosis (IPAA) has become the gold standard operation performed for patients suffering from chronic/refractory ulcerative colitis and familial adenomatous polyposis (FAP). This operation offers complete resection of the involved colon and rectum with the additional benefit of restoring a continuous GI tract (usually a 2 or 3 stage process when including a de-functioning ileostomy). Great strides have been achieved since this operation was first described in 1978 [1], including the introduction of the laparoscopic approach [2] and other evolving techniques [3]. While IPAA offers excellent functional outcomes it remains a complex procedure with significant risk of morbidity [4]. To this end, determining the safest and most beneficial approach to performing this operation remains important.

Most studies on IPAA outcomes support the notion that the laparoscopic approach is effective and safe, but have yet to demonstrate any significant advantages over the open approach. A review of the results of these prior studies is listed in Table 1. Technical limitations and disappointing results from early studies have prevented the laparoscopic approach from becoming the standard of care [5]. Ongoing studies evaluating the possible benefits of the laparoscopic IPAA are necessary. This study aims to utilize the abundance of data gathered by the ACS-NSQIP proctectomy-specific program to compare surgical outcomes of open and laparoscopic IPAA creations.

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Table 1
Laparoscopic Vs. Open IPAA Review.

Year	Author	Lap (n)	Open (n)	Single vs Multi Institution	NSQIP	Result
1994	Schmitt [6]	22	20	Single	NO	No difference in duration of ileus or length of hospitalization
2000	Marcello [7]	20	20	Single	NO	Lap group: Longer operative time (330 vs 230 min, p=<0.001), quicker ROBF (2 vs 4 d, p=0.030), shorter length of hospitalization (7 vs 8, p=0.02)
2001	Otani [8]	10	18	Single	NO	Lap group: Decreased length of hospitalization after start of eating (14.9 vs 23.8 d, p=<0.01) No data on post-op complications.
2001	Araki [9]	21	11	Single	NO	Lap group: Quicker ROBF (1.7 vs 5.4 d, p=<0.05). No difference in morbidity.
2001	Brown [10]	12	13	Single	NO	Lap group: Longer operative time (150 vs 120 min, p=<0.01). No other differences.
2001	Dunker [11]	15	17	Single	NO	No differences in functional outcomes or QOL indices.
2001	Hashimoto [12]	11	13	Single	NO	Lap group: Longer operative time (483 vs 402 min., p=<0.05), shorter length of hospitalization (24.1 vs 31.3 d, p=<0.05)
2004	Berdah [13]	12	12	Single	NO	Lap group: Longer operative time (400 vs 300 min, p=0.003), quicker ROBF (1 vs 3 d, p=0.009)
2004	Maartense [14]	30	30	Multi (2)	NO	**RCT** Lap group: Longer operative time (210 vs 133 min, p=<0.001) No difference in QOL, morbidity of length of stay
2005	Larson [15]	33	33	Single	NO	No significant differences in morbidity, functional outcomes or QOL.
2006	Larson [16]	100	200	Single	NO	Lap group (including hand-assisted): Longer operative time (333 vs 230 min, p=<0.0001), quicker ROBF (through ileostomy) (2 v s 3 d, p=0.016), shorter length of stay (4 vs 4 d, <0.0001) No difference in morbidity, readmission, reoperation.
2008	Ouaïssi [17]	23	22	Single	NO	3-stage IPAA. Lap group: Reduced cumulative length of stay (27 vs 39 d, p=<0.05). No significant difference in major complication rate (21.7 vs 40.9%, p=NS)
2009	El-Gazzaz [18]	119	238	Single	NO	Lap group: quicker ROBF (through stoma) (2d vs 3d, p=0.001), and shorter hospital stay (5 vs 6 d, p=0.001). Longer operative time (272 vs 163 min., p=0.04)
2010	Fajardo [19]	55	69	Single	NO	2-stage IPAA. Lap group: Faster time to ileostomy closure. No differences in outcomes
2011	Fleming [20]	339	337	Multi	YES (2005-2008)	Lap group: **Reduction in major (OR = 0.67, 95% CI: 0.45-0.99, P = .04) and minor complications (OR = 0.44, 95% CI: 0.27-0.70, P = .01)** **, Longer operative time (170 vs 124 min, p=≤0.0001)
2013	Schiessling [21]	21	21	Single	NO	**RCT** No significant difference between groups ***
2014	Kjaer [22]	38	34	Single	NO	No significant difference in post-operative sexual function and body image
2015	Benlice [23]	119	238	Single	NO	No difference in incidence of incisional hernia and SBO (requiring hospitalization or surgery) between groups
2018	Campos [24]	38	25	Single	NO	Lap group: Longer operative time (374 vs 281 min, P=0.003), **decrease in major late morbidity (2.6 vs 16%, p= <0.001) and Late Reoperation (5.2 vs 16%, p= <0.05)**
2018	Mineccia [25]	30	48	Single *	NO	3-stage IPAA. Lap group: Longer operative time (472 vs 403min, p=0.004) No differences in rate of complications
2019	McKenna [26]	132	63	Multi	YES (2012-2015)	Pediatric Lap group: Decreased length of hospitalization (6 vs 8 d, p=<0.01), reduced odds of minor complications
2019	Colombo [27]	100	150	Multi (2)	NO	2/3-stage IPAA. No difference in stoma complications.

*Database from Unit of General and Oncologic Surgery, Torino, Italy. 3 surgeons.
** Reported as No. of patients with 1 or >1 major complication (Death, respiratory, cardiac, VTE, renal failure, organ space infection, sepsis, Return to OR) or minor complication (UTI or incisional infection). No significant difference for individual variables except sepsis (19 vs 37, p=0.01) and incisional infection (19 vs 4, p=.01).
*** No statistical analysis of significance was performed on the data as the trial did not reach their intended number of patients and stopped early (they no longer could recruit patients, as they all preferred the laparoscopic approach).

Material and methods

This study was approved by the Columbia University Medical Center Institutional Review Board (IRB). The American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) is a database comprised of clinical data collected nationally from approximately 700 participating hospitals. Designed as an expansion of the original NSQIP program, ACS-NSQIP is an outcomes-based program that aggregates surgical information on patient demographics, medical comorbidities, laboratory values, operative details, and post-operative complications [28]. ACS-NSQIP began collecting information on colorectal specific variables in 2011-2012, with proctectomy-specific files released starting in 2016. A review of the ACS-NSQIP participant user file (PUF) merged with the proctectomy targeted PUFs was performed. Ileal Pouch Anal Anastomosis operations were identified using primary Current Procedural Terminology (CPT) codes 44157, 44158, 44211, or 45113.

Data definitions were compliant with the ACS_NSQIP Data Dictionary (available online). Variables with missing data include: height, weight, age, ASA class, total hospital length of stay (LOS), creatinine, HCT, WBC, BUN, platelets, and sodium (Appendix A). Aside from two missing ASA Class (imputed to mode), two missing total hospital LOS (imputed to median), and two ages marked 90+ that were turned to 90, all other missing data were imputed via random forest multiple imputation based on other patient characteristic (height, weight, creatinine, BUN, platelets, WBC, HCT, and sodium). Only elective cases were included in the final cohort. Surgical approach groupings were based on intent to treat (Appendix B). Complications that were present at time of operation (PATOS) were not included in the final analysis. Categories that featured some PATOS complications included superficial SSI, deep incisional SSI, organ space SSI, pneumonia, ventilation, sepsis, and septic shock (Appendix C). Additional exclusion criteria included patients who were still in-hospital, patients with an operative time less than 10 minutes (assumed data entry error), MAC/IV anesthesia, surgical specialty marked anything other than general, and patients with no wound closure. Lastly, some fields were collated due to small numbers (Appendix D).

Statistical analysis

Data were expressed as frequencies and percentages for categorical variables and compared using either the Chi-Squared test or the Fisher's

Table 2
Preoperative Patient Characteristics Pre- and Post-Propensity Score Match.

Variable	Unadj. Laparoscopic(N=1001)	Unadj. Open(N=801)	SMD	Adj. Laparoscopic(N=702)	Adj. Open(N=702)	SMD
Age, median [IQR]	41.0 [30.0-55.0]	43.0 [31.0-56.0]	0.058	42.0 [29.0-55.0]	42.0 [30.0-55.0]	0.003
Male Gender, n (%)	568 (56.7)	461 (57.6)	0.016	403 (57.4)	402 (57.3)	0.003
Race, n (%)			0.143			0.076
Asian	37 (3.7)	27 (3.4)		25 (3.6)	22 (3.1)	
Black	31 (3.1)	38 (4.7)		28 (4.0)	27 (3.8)	
Other	125 (12.5)	130 (16.2)		109 (15.5)	92 (13.1)	
White	808 (80.7)	606 (75.7)		540 (76.9)	561 (79.9)	
Ethnicity, n (%)			0.134			0.092
No	862 (86.1)	665 (83.0)		586 (83.5)	608 (86.6)	
Unknown	73 (7.3)	89 (11.1)		67 (9.5)	51 (7.3)	
Yes	66 (6.6)	47 (5.9)		49 (7.0)	43 (6.1)	
Operative Year, n (%)			0.099			0.076
2016	324 (32.4)	265 (33.1)		219 (31.2)	234 (33.3)	
2017	355 (35.5)	249 (31.1)		247 (35.2)	222 (31.6)	
2018	322 (32.2)	287 (35.8)		236 (33.6)	246 (35.0)	
BMI, median [IQR]	25.9 [22.8-29.9]	25.7 [22.5-29.3]	0.062	25.7 [22.7-29.7]	25.8 [22.7-29.4]	0.011
Elective, n (%)	968 (96.7)	761 (95.0)	0.085	674 (96.0)	680 (96.9)	0.046
Diabetes, n (%)	54 (5.4)	50 (6.2)	0.036	41 (5.8)	37 (5.3)	0.025
Smoking, n (%)	101 (10.1)	71 (8.9)	0.042	73 (10.4)	64 (9.1)	0.043
Dyspnea, n (%)	22 (2.2)	17 (2.1)	0.005	15 (2.1)	15 (2.1)	<0.001
Functional Status, n (%)	2 (0.2)	5 (0.6)	0.066	2 (0.3)	0 (0.0)	0.076
COPD, n (%)	8 (0.8)	6 (0.7)	0.006	4 (0.6)	5 (0.7)	0.018
Ascites, n (%)	0 (0.0)	3 (0.4)	0.087	0 (0.0)	0 (0.0)	<0.001
CHF, n (%)	1 (0.1)	2 (0.2)	0.036	1 (0.1)	1 (0.1)	<0.001
HTN, n (%)	160 (16.0)	127 (15.9)	0.004	111 (15.8)	110 (15.7)	0.004
Dialysis, n (%)	1 (0.1)	1 (0.1)	0.007	1 (0.1)	1 (0.1)	<0.001
Disseminated Cancer, n (%)	16 (1.6)	22 (2.7)	0.079	15 (2.1)	14 (2.0)	0.010
Wound Infection, n (%)	5 (0.5)	10 (1.2)	0.081	5 (0.7)	5 (0.7)	<0.001
Steroid Use, n (%)	289 (28.9)	124 (15.5)	0.327	116 (16.5)	115 (16.4)	0.004
Weight Loss, n (%)	42 (4.2)	31 (3.9)	0.017	24 (3.4)	27 (3.8)	0.023
Bleeding Disorder, n (%)	13 (1.3)	19 (2.4)	0.080	13 (1.9)	12 (1.7)	0.011
Transfusion, n (%)	4 (0.4)	6 (0.7)	0.046	4 (0.6)	2 (0.3)	0.044
Sepsis, n (%)	15 (1.5)	13 (1.6)	0.010	13 (1.9)	8 (1.1)	0.059
Emergency, n (%)	6 (0.6)	13 (1.6)	0.098	6 (0.9)	1 (0.1)	0.101
Wound Class, n (%)			0.133			0.064
1	4 (0.4)	7 (0.9)		4 (0.6)	2 (0.3)	
2	742 (74.1)	572 (71.4)		511 (72.8)	514 (73.2)	
3	233 (23.3)	188 (23.5)		167 (23.8)	171 (24.4)	
4	22 (2.2)	34 (4.2)		20 (2.8)	15 (2.1)	
ASA Class, n (%)			0.161			0.048
1	23 (2.3)	18 (2.2)		15 (2.1)	17 (2.4)	
2	615 (61.4)	476 (59.4)		421 (60.0)	433 (61.7)	
3	360 (36.0)	291 (36.3)		263 (37.5)	250 (35.6)	
4	3 (0.3)	16 (2.0)		3 (0.4)	2 (0.3)	
Sodium, median [IQR]	139.0 [138.0-141.0]	139.0 [138.0-141.0]	0.025	139.0 [138.0-141.0]	139.0 [138.0-141.0]	0.025
BUN, median [IQR]	12.0 [9.0-15.0]	12.6 [10.0-16.0]	0.085	13.0 [10.0-16.0]	12.0 [10.0-16.0]	0.032
Creatinine, median [IQR]	0.8 [0.7-1.0]	0.8 [0.7-1.0]	0.003	0.8 [0.7-1.0]	0.8 [0.7-1.0]	0.019
WBC, median [IQR]	7.3 [5.8-9.1]	6.9 [5.6-8.6]	0.134	7.0 [5.7-8.7]	6.9 [5.7-8.7]	0.021
HCT, median [IQR]	40.0 [36.1-43.0]	40.0 [37.0-43.1]	0.057	40.2 [36.7-43.3]	40.0 [37.0-43.1]	0.010
Platelets, median [IQR]	288.0 [233.0-365.0]	271.0 [220.0-330.0]	0.211	275.0 [224.0-336.5]	274.5 [226.0-333.0]	0.024

Unadj=unadjusted; Adj=adjusted; SMD=standardized mean difference; BUN= Blood Urea Nitrogen; WBC=white blood count; HCT=hematocrit

Exact test depending on size (>5). Continuous variables are expressed as either mean (SD) or median (IQR) depending on normality which was tested via the Shapiro-Wilk test. They were compared with either the t-test or Wilcoxon Rank Sum, respectively.

A logistic regression with surgical approach as the dependent variable and all possible preoperative patient characteristics as the independent variables were run. These independent variables were checked for collinearity using the Variance Inflation Factor (VIF>5). No variables were deemed collinear. Next, Propensity score matching (PSM) using all variables in Table 2 was conducted using 1:1 nearest neighbor matching. A 0.2 caliper was used and a standardized mean difference of 0.1 was used to determine matching success. In order to not inflate type I error, Bonferroni correction was applied to outcomes and therefore a p-value of <0.002 is deemed significant. R statistical software (version 4.0.2, R Foundation) was used for statistical analyses.

Theory

An analysis of ACS-NSQIP data collected during 2005-2008, comparing open and laparoscopic IPAA with a diverting ileostomy, reported a reduced rate of both major and minor complications during the 30-day post-operative period with the laparoscopic approach [20]. The ACS-NSQIP began to collect information regarding colorectal-specific variables in 2012. There has been only one study that we identified, and in the pediatric population, utilizing these data to study the impact of surgical approach on IPAA outcomes. When comparing laparoscopic

Table 3
Outcomes Pre- and Post-Propensity Score Match.

Variable	Unadj. Laparoscopic (N=1001)	Unadj. Open (N=801)	p-value	Adj. Laparoscopic (N=702)	Adj. Open (N=702)	p-value
Operative Time, median [IQR]	285.0 [222.0-369.0]	220.0 [165.0-296.0]	<0.001	278.0 [217.0-359.8]	218.5 [165.0-296.0]	<0.001*
Total Hospital LOS, median [IQR]	5.0 [4.0-8.0]	6.0 [4.0-8.0]	<0.001	5.0 [4.0-8.0]	6.0 [4.0-8.0]	0.004
Anastomotic Leak, n (%)	40 (4.0)	32 (4.0)	1.0	28 (4.0)	23 (3.3)	0.6
In-hospital Mortality, n (%)	3 (0.3)	2 (0.2)	1.0	3 (0.4)	0 (0.0)	0.3
Superficial/Deep Infection, n (%)	29 (2.9)	60 (7.5)	<0.001	21 (3.0)	46 (6.6)	0.003*
Organ Space SSI, n (%)	76 (7.6)	57 (7.1)	1.0	47 (6.7)	46 (6.6)	1.0
Dehiscence, n (%)	2 (0.2)	3 (0.4)	1.0	1 (0.1)	2 (0.3)	1.0
Pneumonia, n (%)	14 (1.4)	7 (0.9)	0.4	8 (1.1)	2 (0.3)	0.1
Reintubation/Prolonged Ventilation, n (%)	8 (0.8)	1 (0.1)	0.5	7 (1.0)	0 (0.0)	0.02
Pulmonary Embolism/DVT, n (%)	25 (2.5)	15 (1.9)	0.5	14 (2.0)	12 (1.7)	0.8
Renal Insufficiency/Failure, n (%)	18 (1.8)	14 (1.7)	1	15 (2.1)	11 (1.6)	0.6
Stroke/CVA, n (%)	1 (0.1)	0 (0.0)	1	1 (0.1)	0 (0.0)	1
Cardiac Arrest/MI, n (%)	3 (0.3)	2 (0.2)	1	3 (0.4)	1 (0.1)	0.6
Bleed Requiring Transfusion, n (%)	56 (5.6)	58 (7.2)	0.2	40 (5.7)	44 (6.3)	0.7
Sepsis/Septic Shock, n (%)	36 (3.6)	32 (4.0)	1.0	27 (3.8)	24 (3.4)	0.8
Reoperation, n (%)	58 (5.8)	36 (4.5)	0.3	40 (5.7)	28 (4.0)	0.2

Unadj=unadjusted; Adj=adjusted; SMD=standardized mean difference; LOS=length of stay; SSI=surgical site infection; DVT=deep vein thrombosis; CVA=cerebrovascular accident; MI=myocardial infarction
*Bonferroni Correction Deems Significant

vs. open TPC-IPAA in the pediatric population, the laparoscopic approach was associated with a decrease in minor complications such as superficial surgical site infection and urinary tract infection and length of stay [26].

A meta-analysis of 11 studies comparing open and laparoscopic proctocolectomy with IPAA revealed no significant difference in clinical outcomes between the two groups [29]. That meta-analysis included the only complete randomized control trial ever performed, comparing laparoscopic hand-assisted and open proctocolectomy with IPAA. That study also reported similar recovery patterns between the two approaches using verified quality of life indices [30]. As most patients prefer laparoscopic surgery when given a choice, prospective studies comparing the open and laparoscopic approaches may be challenging to perform. Utilizing the available retrospective data is therefore essential in further delineating whether there are distinct clinical benefits of the laparoscopic approach for this complex operation.

Results

Demographic and clinical data

A total of 1802 patients who underwent proctocolectomy with IPAA were identified and included in the analysis. In the unadjusted cohort, there were 1001 patients in the laparoscopic group (55.5%) and 801 (44.5%) in the open group. In the unadjusted cohort, the median age was 41 years for the laparoscopic group and 43 years for the open group. The majority of patients in both the laparoscopic and open groups were male (56.7% and 57.6%, respectively) and white (80.7% and 75.7%). Median BMI among both groups were at the upper limit of normal. The preoperative medical history and laboratory work of patients in both groups were generally equivalent. More patients in the laparoscopic groups were listed as using steroids chronically (28.9% vs 15.5%). Using 32 variables, PSM matching was successful (all SMD <0.1) with 702 patients in each matched group. All demographic information and clinical characteristics of the patient groups are listed in Table 2, both pre and post-PSM.

Adjusted surgical outcomes

Thirty-day post-operative complications, with pre and post- PSM adjustment values, are listed in Table 3. Following PSM and using Bonferroni Correction, there was a decrease in the incidence of superficial and deep surgical site infections between the laparoscopic and open groups (3.0% vs 6.6%, p=0.003). Laparoscopic cases were longer than open cases (278 min. IQR [217.0-359.8] vs. 218.5 min. IQR [165.0-296.0], p<0.001). Length of stay was shorter in the laparoscopic group (5 d. vs 6 d, p=0.004), although it did not reach statistical significance by Bonferonni correction. Similarly, with the Bonferroni correction there was no difference in the incidence of reintubation or prolonged ventilation between laparoscopy and open groups but it is worth noting (1% vs 0%, p=0.02).

There was no difference in anastomotic leak, organ space surgical site infection, or septic complications between the two surgical approaches. Laparoscopic IPAA was not associated with an increase in thirty-day reoperation or mortality as compared to open.

Discussion

Ileal Pouch-Anal Anastomosis remains the gold standard for patients undergoing proctocolectomy for ulcerative colitis and FAP. However, there still lacks any significant evidence of the benefits of laparoscopy for IPAA. While even the earliest studies demonstrated the safety and feasibility of the laparoscopic approach [6,31,32], few studies since have demonstrated significant benefits over the open approach. In addition, most studies comparing the two surgical approaches are single-institution with small patient sample sizes (Table 1). The largest study to date, from the Cleveland Clinic, reported no difference in thirty-day or long-term outcomes between groups, aside from shorter hospital stay. There also was no significant difference in reported quality of life or functional outcomes between groups at 1 and 5 year follow-ups [18].

There have only been two randomized controlled trials performed comparing laparoscopic and open IPAA. The first compared 30 patients in each group (hand-assisted laparoscopic vs open), with no difference in morbidity or mortality between groups demonstrated [28]. The second trial of its kind, the LapConpouch Trial, was prematurely stopped due to problems with patient recruitment. Interestingly, overwhelming patient preference for the laparoscopic approach was the cause of recruitment failure [21].

Our study utilizes the large ACS-NSQIP database and proctectomy-specific outcomes data to compare the laparoscopic and open IPAA. This represents the largest of its kind, with a total of 702 PSM-matched pairs. There was no difference in thirty-day post-operative morbidity or mortality when compared to the open approach, again reaffirming its

Appendix A
Missing Data of the final N=1802 cohort.

Variable	N(%)	How dealt with
Height	12 (0.67%)	Random Forest Multiple Imputation
Weight	10 (0.55%)	Random Forest Multiple Imputation
Age 90+	2 (0.11%)	Turned to 90
ASA Class	3 (0.17%)	Imputed to the mode
Total Hospital LOS	2 (0.11%)	Imputed to the median
Creatinine	231 (12.82%)	Random Forest Multiple Imputation
WBC	177 (9.82%)	Random Forest Multiple Imputation
HCT	162 (8.99%)	Random Forest Multiple Imputation
BUN	310 (17.20%)	Random Forest Multiple Imputation
Platelets	176 (9.77%)	Random Forest Multiple Imputation
Sodium	243 (13.49%)	Random Forest Multiple Imputation

safety. The laparoscopic approach had the advantage of being associated with a reduced incidence of superficial and deep surgical site infections. Operative time was significantly longer in the laparoscopic group, as is expected and consistent with previous studies. Similar to previous studies, there was a shorter LOS for patients undergoing laparoscopic IPAA.

The validated data from ACS-NSQIP allows for study of a large sample size, and is somewhat representative of multiple institutions across the country. The proctectomy-specific data, first collected starting in 2016, allows for inclusion of some important colorectal-specific post-operative complications, such as anastomotic leak. It should be noted that information on the presence or absence of ileus for our subset of patients was not available. In addition, this study does not include other IPAA cases in the ACS-NSQIP database from prior to the year 2016, as it could not be merged with the proctectomy-specific ACS-NSQIP files. Limitations of the ACS-NSQIP database include the absence of data regarding surgeon-experience and institution-specific factors that may impact results. This dataset also does not distinguish between 2 vs. 3 stage IPAA procedures and does not report on use of mechanical bowel prep, preoperative antibiotics, and skin preparation protocols. Additional studies focusing on the long-term results of laparoscopic IPAA remain necessary, as well as true randomized-controlled trials.

Conclusions

In conclusion, laparoscopic IPAA creation is shown to be safe without additional risk of morbidity/mortality as compared to the open approach with the retrospective review of the NSQIP database. It is also associated with decreased risk of superficial and deep surgical site infections. Laparoscopy should be a preferentially considered surgical approach for patients undergoing IPAA creation.

Author contributions

All authors made substantial contributions to this manuscript, including the study conception, data collection, analysis of results, and manuscript preparation. All authors reviewed the results and approved the final version of the manuscript.

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There are no financial conflicts of interest to disclose. There are no further sources of financial support to acknowledge.

Ethics approval

This work has been approved by the appropriate ethical committee at our institution.

Appendix B
Surgical Approaches Included.

Laparoscopic	Laparoscopic with open assist, Laparoscopic with unplanned conversion to open, Robotic, Robotic with open assist, SILS, SILS with open assist, SILS with unplanned conversion to open, Robotic with unplanned conversion to open
Open	Open (planned)

Appendix C
Exclusions.

Variable	N	How dealt with
Superficial SSI PATOS	3	Excluded from Analysis
Deep Incisional SSI PATOS	1	Excluded from Analysis
Organ Space SSI PATOS	13	Excluded from Analysis
Pneumonia PATOS	0	Excluded from Analysis
Ventilation PATOS	0	Excluded from Analysis
Sepsis PATOS	6	Excluded from Analysis
Septic Shock PATOS	0	Excluded from Analysis
Wound Closure (Not closed)	1	Excluded from Analysis
Still In-hospital	19	Excluded from Analysis
Operative Time < 10 min	2	Excluded from Analysis
MAC/IV Anesthesia	1	Excluded from Analysis
Non-general surgery specialty	3	Excluded from Analysis

*a patient may have more than one exclusion so counts do not add up to the total number of patients excluded

Appendix D
Data Collation of the final N=1802 cohort.

Variable	N	How Collated
American Indian	7	Collated with Race Other
Pacific Islander	3	
Insulin Diabetes	43	Collated to be Diabetes Yes
Non-insulin Diabetes	61	
Dyspnea At Rest	2	Collated to be Dyspnea Yes
Dyspnea On Moderate Exertion	37	
Partial Dependent Functional Status	6	Collated to be Functional Status Dependent
Totally Dependent Functional Status	1	
Sepsis	3	Collated to be Yes in Preop Sepsis field
Septic Shock	0	
SIRS	25	

Conflict of Interest Statement

The authors declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.sipas.2022.100114.

Appendices

Appendix A, B, C, D

References

[1] Parks AG, Nicholls RJ. Proctocolectomy without ileostomy for ulcerative colitis. Br Med J Jul 8 1978;2(6130):85–8. https://doi.org/10.1136/bmj.2.6130.85.
[2] Kienle P, Z'graggen K, Schmidt J, Benner A, Weitz J, Büchler MW. Laparoscopic restorative proctocolectomy. Br J Surg Jan 2005;92(1):88–93. https://doi.org/10.1002/bjs.4772.
[3] Lovegrove RE, Constantinides VA, Heriot AG, Athanasiou T, Darzi A, Remzi FH, Nicholls RJ, Fazio VW, Tekkis PP. A comparison of hand-sewn versus stapled ileal pouch anal anastomosis (IPAA) following proctocolectomy: a meta-analysis of 4183 patients. Ann Surg Jul 2006;244(1):18–26. https://doi.org/10.1097/01.sla.0000225031.15405.a3.

[4] Buskens CJ, Sahami S, Tanis PJ, Bemelman WA. The potential benefits and disadvantages of laparoscopic surgery for ulcerative colitis: A review of current evidence. Best Pract Res Clin Gastroenterol Feb 2014;28(1):19–27. https://doi.org/10.1016/j.bpg.2013.11.007.
[5] Bemelman WA. Laparoscopic ileoanal pouch surgery. Br J Surg Jan 2010;97(1): 2–3. https://doi.org/10.1002/bjs.6817.
[6] Schmitt SL, Cohen SM, Wexner SD, Nogueras JJ, Jagelman DG. Does laparoscopic-assisted ileal pouch anal anastomosis reduce the length of hospitalization? Int J Colorectal Dis Aug 1994;9(3):134–7. https://doi.org/10.1007/BF00290189.
[7] Marcello PW, Milsom JW, Wong SK, Hammerhofer KA, Goormastic M, Church JM, et al. Laparoscopic restorative proctocolectomy: case-matched comparative study with open restorative proctocolectomy. Dis Colon Rectum 2000;43(5):604–8. https://doi.org/10.1007/BF02235570.
[8] Otani Y, Nakamura T, Kanazawa H, Aihara N, Kokuba Y, Ihara A, Kakita A. Laparoscopy-assisted ileal-pouch anal-canal anastomosis for ulcerative colitis, Japanese Journal of Gastroenterological Surgery 2001;34 (4): 351-356.
[9] Araki Y, Ishibashi N, Ogata Y, Shirouzu K, Isomoto H. The usefulness of restorative laparoscopic-assisted total colectomy for ulcerative colitis. Kurume Med J 2001;48 (2):99–103. https://doi.org/10.2739/kurumemedj.48.99.
[10] Brown SR, Eu KW, Seow-Choen F. Consecutive series of laparoscopic-assisted vs. minilaparotomy restorative proctocolectomies. Dis Colon Rectum 2001;44(3): 397–400. https://doi.org/10.1007/BF02234739.
[11] Dunker MS, Bemelman WA, Slors JF, van Duijvendijk P, Gouma DJ. Functional outcome, quality of life, body image, and cosmesis in patients after laparoscopic-assisted and conventional restorative proctocolectomy: A comparative study. Dis Colon Rectum 2001;44(12):1800–7. https://doi.org/10.1007/BF02234458.
[12] Hashimoto A, Funayama Y, Naito H, Fukushima K, Shibata C, Naitoh T, et al. Laparascope-assisted versus conventional restorative proctocolectomy with rectal mucosectomy. Surg Today 2001;31(3):210–4. https://doi.org/10.1007/s005950170170.
[13] Berdah SV, Barthet M, Emungania O, Orsoni P, Alliot P, Grimaud JC, Brunet C. Coloproctectomie totale avec anastomose iléoanale en deux temps vidéoassistée. Expérience initiale de 12 cas [Two stage videoassisted restorative proctocolectomy, Early experience of 12 cases] . Ann Chir. 2004;129 (6-7):332-6. doi: 10.1016/j.anchir.2004.04.012.
[14] Maartense S, Dunker MS, Slors JF, Cuesta MA, Gouma DJ, van Deventer SJ, van Bodegraven AA, Bemelman WA., Hand-assisted laparoscopic versus open restorative proctocolectomy with ileal pouch anal anastomosis: A randomized trial. Ann Surg. 2004 ;240(6):984-91; discussion 991-2. doi: 10.1097/01.sla.0000145923.03130.1c.
[15] Larson DW, Dozois EJ, Piotrowicz K, Cima RR, Wolff BG, Young-Fadok TM. Laparoscopic-assisted vs. open ileal pouch-anal anastomosis: functional outcome in a case-matched series. Dis Colon Rectum 2005;48(10):1845–50. https://doi.org/10.1007/s10350-005-0143-4.
[16] Larson DW, Cima RR, Dozois EJ, Davies M, Piotrowicz K, Barnes SA, et al. Safety, feasibility and short-term outcomes of laparoscopic ileal-pouch-anal anastomosis: a single institutional case-matched experience. Ann Surg 2006;243(5):667–70.
[17] Ouaïssi M, Lefevre JH, Bretagnol F, Alves A, Valleur P, Panis Y. Laparoscopic 3-step restorative proctocolectomy: comparative study with open approach in 45 patients. Surg Laparosc Endosc Percutan Tech 2008;18(4):357–62. https://doi.org/10.1097/SLE.0b013e3181772d75.
[18] El-Gazzaz GS, Kiran RP, Remzi FH, Hull TL, Geisler DP. Outcomes for case-matched laparoscopically assisted versus open restorative proctocolectomy. Br J Surg May 2009;96(5):522–6. https://doi.org/10.1002/bjs.6578.
[19] Fajardo AD, Dharmarajan S, George V, Hunt SR, Birnbaum EH, Fleshman JW, et al. Laparoscopic versus open 2-stage ileal pouch: laparoscopic approach allows for faster restoration of intestinal continuity. J Am Coll Surg 2010;211(3):377–83. https://doi.org/10.1016/j.jamcollsurg.2010.05.018.
[20] Fleming FJ, Francone TD, Kim MJ, Gunzler D, Messing S, Monson JR. A laparoscopic approach does reduce short-term complications in patients undergoing ileal pouch-anal anastomosis. Dis Colon Rectum Feb 2011;54(2): 176–82. https://doi.org/10.1007/DCR.0b013e3181fb4232.
[21] Schiessling S, Leowardi C, Kienle P, Antolovic D, Knebel P, Bruckner T, Kadmon M, Seiler CM, Büchler MW, Diener MK, Ulrich A. Laparoscopic versus conventional ileoanal pouch procedure in patients undergoing elective restorative proctocolectomy (LapConPouch Trial)-a randomized controlled trial. Langenbecks Arch Surg Aug 2013;398(6):807–16. https://doi.org/10.1007/s00423-013-1088-z.
[22] Kjaer MD, Laursen SB, Qvist N, Kjeldsen J, Poornoroozy PH. Sexual function and body image are similar after laparoscopy-assisted and open ileal pouch-anal anastomosis. World J Surg 2014;38(9):2460–5. https://doi.org/10.1007/s00268-014-2557-4.
[23] Benlice C, Stocchi L, Costedio M, Gorgun E, Hull T, Kessler H, et al. Laparoscopic IPAA is not associated with decreased rates of incisional hernia and small-bowel obstruction when compared with open technique: long-term follow-up of a case-matched study. Dis Colon Rectum 2015;58(3):314–20. https://doi.org/10.1097/DCR.0000000000000287.
[24] Campos FG, Real Martinez CA, Monteiro de Camargo MG, Cesconetto DM, Nahas SC, Cecconello I. Laparoscopic Versus Open Restorative Proctocolectomy for Familial Adenomatous Polyposis. J Laparoendosc Adv Surg Tech A 2018;28(1): 47–52. https://doi.org/10.1089/lap.2017.0397.
[25] Mineccia M, Cravero F, Massucco P, Portigliotti L, Bertolino F, Daperno M, et al. Laparoscopic vs open restorative proctocolectomy with IPAA for ulcerative colitis: Impact of surgical technique on creating a well functioning pouch. Int J Surg 2018; 55:201–6. https://doi.org/10.1016/j.ijsu.2018.04.006.
[26] McKenna NP, Potter DD, Bews KA, Glasgow AE, Mathis KL, Habermann EB. Ileal-pouch anal anastomosis in pediatric NSQIP: Does a laparoscopic approach reduce complications and length of stay? J Pediatr Surg Jan 2019;54(1):112–7. https://doi.org/10.1016/j.jpedsurg.2018.10.005.
[27] Colombo F, Pellino G, Selvaggi F, Corsi F, Sciaudone G, Sampietro GM, et al. Minimally invasive surgery and stoma-related complications after restorative proctocolectomy for ulcerative colitis. A two-centre comparison with open approach. Am J Surg 2019;217(4):682–8. https://doi.org/10.1016/j.amjsurg.2018.07.028.
[28] Khuri SF. The NSQIP: a new frontier in surgery. Surgery Nov 2005;138(5):837–43. https://doi.org/10.1016/j.surg.2005.08.016.
[29] Ahmed Ali U, Keus F, Heikens JT, Bemelman WA, Berdah SV, Gooszen HG, van Laarhoven CJ. Open versus laparoscopic (assisted) ileo pouch anal anastomosis for ulcerative colitis and familial adenomatous polyposis. Cochrane Database Syst Rev. 2009 Jan 21;(1):CD006267. doi: 10.1002/14651858.CD006267.pub2.
[30] Maartense S, Dunker MS, Slors JF, Cuesta MA, Gouma DJ, van Deventer SJ, van Bodegraven AA, Bemelman WA. Hand-assisted laparoscopic versus open restorative proctocolectomy with ileal pouch anal anastomosis: a randomized trial. Ann Surg Dec 2004;240(6):984–91. https://doi.org/10.1097/01.sla.0000145923.03130.1c. discussion 991-2.
[31] Reissman P, Salky BA, Pfeifer J, Edye M, Jagelman DG, Wexner SD. Laparoscopic surgery in the management of inflammatory bowel disease. Am J Surg Jan 1996; 171(1):47–50. https://doi.org/10.1016/s0002-9610(99)80072-5. discussion 50-1.
[32] Santoro E, Carlini M, Carboni F, Feroce A. Laparoscopic total proctocolectomy with ileal J pouch-anal anastomosis. Hepatogastroenterology Mar-Apr 1999;46(26): 894–9.