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Authors

Sujatha-Bhaskar, Sarath
Whealon, Matthew
Inaba, Colette
et al.

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Laparoscopic loop ileostomy reversal with intracorporeal anastomosis is associated with shorter length of stay without increased direct cost

Sarath Sujatha-Bhaskar[1], **Matthew Whealon**[1], **Colette S. Inaba**[1], **Christina Y. Koh**[1], **Mehraneh D. Jafari**[1], **Steven Mills**[1], **Alessio Pigazzi**[1], **Michael J. Stamos**[1], **Joseph C. Carmichael**[1,2]

[1]Department of Surgery, University of California Irvine School of Medicine, Irvine, CA, USA

[2]Department of Surgery, University of California, Irvine, 333 City Blvd. W. Ste. 850, Orange, CA 92868, USA

Abstract

Background—Laparoscopic ileostomy closure with intracorporeal anastomosis offers potential advantages over open reversal with extracorporeal anastomosis, including earlier return of bowel function and reduced postoperative pain. In this study, we aim to compare the outcome and cost of laparoscopic ileostomy reversal (utilizing either intracorporeal or extracorporeal anastomosis) with open ileostomy reversal.

Methods—A retrospective review of sequential patients undergoing elective loop ileostomy reversal between 2013 and 2016 at a single, high-volume institution was performed. Patients were stratified on the basis of operative approach: open reversal, laparoscopic-assisted reversal with extracorporeal anastomosis (LE), and laparoscopic reversal with intracorporeal anastomosis (LI). Linear and logistic regressions were utilized to perform multivariate analysis and determine risk-adjusted outcomes.

Results—Of 132 sequential cases of loop ileostomy reversal, 50 (38%) underwent open, 49 (37%) underwent LE, and 33 (22%) underwent LI. Demographic data and preoperative comorbidities were similar between the three cohorts. Median length of stay was significantly shorter for LI (52.1 h, $p < 0.05$) compared to open (69.0 h) and LE (69.6 h). After risk-adjusted analysis, length of stay was significant shorter in LI compared to LE (GM 0.78, 95% CI 0.64–0.93, $p < 0.01$) and open reversal (GM 0.78, 95% CI 0.66–0.93, $p < 0.01$). Risk-adjusted 30-day morbidity rates were similar for LI compared to LE (OR 0.43, 95% CI 0.081–2.33, $p = 0.33$) and open reversal (OR 0.53, 95% CI 0.09–3.125, $p = 0.48$). Median in-hospital direct cost was similar for LI ($6575.00), LE ($6722.50), and open reversal ($6181.00).

Joseph C. Carmichael, jcarmich@uci.edu.

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Conclusion—Laparoscopic ileostomy reversal with intracorporeal anastomosis was associated with shorter length of stay without increased overall direct cost. The technique of laparoscopic ileostomy reversal warrants continued study in a randomized clinical trial.

Keywords

Laparoscopy; Loop Ileostomy; Intracorporeal; Anastomosis

Current colorectal practices have advocated selective application of loop ileostomy during the creation of high risk, low pelvic (colorectal and ileoanal) anastomoses to mitigate the effects of leak [1]. With increasing rates of sphincter-preserving operations and low pelvic anastomoses, diverting loop ileostomy creation has become more prevalent [2, 3]. Risk factors associated with anastomotic leak have included male gender, advanced age, malnutrition, neoadjuvant chemoradiotherapy, prolonged operative duration, and perioperative transfusion requirements [4–7]. Given the devastating effect of leak in postoperative outcomes, the creation of defunctioning stoma has been demonstrated to beneficially reduce morbidity and intervention associated with anastomotic leak [8–10].

Early loop ileostomy reversal has been associated with better functional outcome with some centers reporting reversal even as early as 8–13 days [11, 12]. An open approach through circumferential dissection at the stoma site and anastomosis of the proximal and distal ileum has been standardly employed. However, there has been a progressive adoption of minimally invasive laparoscopic techniques in intestinal surgery in light of benefits such as reduction in postoperative complication rates, earlier return of bowel function, and shorter hospitalization duration [13–15]. Prior studies have documented higher operating room costs associated with laparoscopic intestinal surgery, whereas an open approach has been associated with increased postoperative cost related to complications and length of stay [16].

Colorectal surgeons at our institution began the routine adoption of a laparoscopic approach to ileostomy reversal in 2013. This included application of intracorporeal reconstruction techniques which have previously been shown to reduce incision size and wound-related complications when used in right colectomies [17]. In our study of cases at a single high-volume institution, we examined outcomes associated with three ileostomy reversal techniques: laparoscopic intracorporeal reversal, laparoscopic extracorporeal reversal, and open reversal.

Methods

Patient selection

Our study consisted of a retrospective, sequential examination of clinical patient data acquired from electronic medical records that were reviewed over our study time period. From February 2013 to June 2016, patients over the age of 18 who underwent elective loop ileostomy reversal by surgeons in the colorectal surgery division in a single, high-volume institution were identified and included in this study. Permission to perform this study was obtained from the institutional review board at the University of California, Irvine.

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Over the course of this study period, our colorectal surgeons routinely began to employ laparoscopic intracorporeal and extracorporeal loop ileostomy reversal in their practices. Cases performed by surgeons outside the division of colon and rectal surgery were excluded as differences in operative approach and indication may be present. Additionally, any loop ileostomy operations that featured ancillary procedures such as complex abdominal wall repair, additional bowel resection, or anastomotic revision were excluded from the study. Cases were stratified into three principal groups: laparoscopic reversal with intracorporeal anastomosis, laparoscopic reversal with extracorporeal anastomosis, and open reversal. The steps for each operative technique were equivalent among our colorectal surgeons.

During the course of our study period, equivalent postoperative enhanced recovery regimens were employed for all patients. All patients were offered a diet postoperatively with employment of a multi-modal, narcotic-sparing pain regimen. This postoperative multimodal pain regimen featured intravenous ketorolac, oral acetaminophen, and oral gabapentin. Any subsequent variation in treatment regimen occurred on a patient-specific basis at the discretion of the primary surgeon. Equivalent discharge criteria were employed which required tolerance of oral intake, patient-appropriate physical activity/ambulation, and adequate pain control on an oral regimen.

Operative technique

For laparoscopic loop ileostomy reversal with intracorporeal anastomosis (LI), a 3-port approach is typically employed. Pneumoperitoneum is achieved after placement of a Veress needle in the left upper quadrant at Palmer's point. A 5 mm laparoscopic port is placed in the left upper quadrant for the laparoscopic 30-degree or flexible tip camera and an additional 12 mm port and 5 mm port are placed in the left mid-abdomen and left lower abdomen respectively. Laparoscopic lysis of adhesions is performed to clearly demarcate the loop ileostomy and dissect it from any attachments to the peritoneum. The ileum proximal and distal to the loop ileostomy is clearly identified and transected with a laparoscopic endo-GIA (gastro-intestinal anastomosis) stapler. A stay suture is placed to oppose the antimesenteric edges of the proximal and distal bowel staple lines. Enterotomies are created proximally and distally and a side-to-side antiperistaltic anastomosis is fashioned with a laparoscopic stapler. The common enterotomy is then closed with either a stapler or with laparoscopic intracorporeal suturing. The laparoscopic ports are withdrawn and their skin incisions closed. The ileostomy is externally resected from the skin edge with subsequent primary closure of the stoma fascial defect. An absorbable suture is placed in a purse-string fashion in the subcuticular layer around a gauze wick for closure by secondary intention (Supplemental Video 1).

For laparoscopic loop ileostomy reversal with extracorporeal anastomosis (LE), a similar initial 3-port approach is employed for laparoscopic lysis of adhesions and intraperitoneal dissection of the loop ileostomy. After adequate laparoscopic lysis of adhesions and mobilization, the operation is converted to an open procedure with circumferential dissection of the ileostomy from the skin, subcutaneous tissue, and fascia. After externalization of the proximal and distal ileum, a side to side antiperistaltic anastomosis is created with a GIA stapler. Primary fascial closure and purse-string skin closure are performed as described for intracorporeal anastomosis.

The open ileostomy approach features external circumferential dissection of the loop ileostomy with externalization of the proximal and distal ileum around the stoma and subsequent stapled small bowel anastomosis. Similar fascial closure and skin closure techniques were used.

Outcome variables

Sequential cases through our study time period were included in our review. Demographic characteristics for each group including age, gender, ethnicity, and body mass index (BMI) were reviewed. Patient medical comorbidities for the following organ systems were reviewed: cardiovascular, pulmonary, renal, hepatic, endocrine, and hematologic/oncologic. Patient functional status was reviewed as well. Analysis of the antecedent surgery during which the loop ileostomy was created was performed. Antecedent surgery indication and surgery type were both reviewed.

Analysis of intraoperative outcomes was performed, including review of total intraoperative case duration, need for adhesiolysis, estimated blood loss, and conversion rate to midline laparotomy. Postoperative outcomes reviewed included overall length of hospital stay(LOS), 30-day morbidity, 30-day mortality, and 30-day readmission. The following postoperative complications were reviewed: stroke/cerebrovascular accident, acute coronary syndrome, pneumonia, ventilator dependency, pulmonary embolism, ileus, anastomotic leak, postoperative bleeding, postoperative transfusion, surgical site infection, urinary retention, and urinary tract infection. Median direct and total in-hospital cost in dollars was determined for each cohort. Direct cost included both variable and fixed expenses associated with the patient's hospitalization.

Statistical methods

Cases were grouped by procedure type for our statistical analysis. Univariate analysis of demographics, comorbidities, and operative characteristics was achieved through Pearson Chi Square testing for binary variables and unpaired Student's *T* testing for continuous variables. The LI cohort was employed as the baseline group for all univariate comparisons. Multivariate analysis of short-term outcomes was performed through linear regression for continuous variables (total cost, direct cost, LOS) and logistic regression for categorical variables (30-day morbidity). *P* values were adjusted for multiple comparisons by Holm's method and robust standard errors were used to guard against model misspecification. All data management was performed using SAS, version 9.4 (Cary, NC, 2016) and all analyses were completed using the computer and programming environment R (Vienna, Austria 2016).

Results

Over our study period, 132 consecutive cases were identified of which 25% underwent LI, 37% underwent LE, and 38% underwent open reversal. Over the course of our study period, laparoscopic intracorporeal and extracorporeal technique were increasingly implemented over an open approach. Demographic characteristics of the three groups were reviewed (Table 1). Mean age was similar at 51.4 ± 15 years in the LI group, 56.8 ± 13.8 years in the LE group, and 51.0 ± 14.3 years in the open group. Gender and ethnic distribution were similar among the 3 cohorts. Mean BMI (kg/m^2) was similar among the three groups (LI: 26.4 ± 4.6, LE: 25.4 ± 5.2, Open 24.4 ± 4.4). Patient comorbidities and operative characteristics were reviewed in Table 2. A similar distribution of patient medical comorbidities and functional status was noted among all three cohorts. An open approach for the antecedent operation (index surgery during which the loop ileostomy was initially created) was more prevalent in open ileostomy reversal group (38%) compared to 9.1% in the LI group and 8.2% in the LE group. With respect to antecedent operation, a combined laparoscopic/robotic approach was employed in 39% of LI, 51% of LE, and 34% of open reversal. Rectal cancer was the most common antecedent indication for operative intervention (LI 64%, LE 65%, Open 38%).

Postoperative outcomes were summarized in Table 3. Median length of stay for LI was 52.1 h (IQR 47.6–72.9 h) compared to LE at 69.6 h (IQR 50.7–98.4 h) and open technique at 69.0 h (IQR 51.4–93.3 h). Rates of concomitant intraperitoneal adhesiolysis were similar at 54% in LI, 69% in LE, and 56% in open reversal. Thirty-day morbidity rates were similarly low among the three groups (LI 6.1%, LE 14.3%, Open 10%). Median direct cost was statistically similar in LI at $6575.00 (IQR $5740.50–7920.00), LE $6722.50 (IQR $5715.00–8635.00), and open reversal $6181 (5459.00–8440.00).

Multivariate analysis was performed including adjustment to the following covariates: patient demographic characteristics, BMI, and all patient medical comorbidities. With respect to the geometric mean (GM) for length of hospital stay, LI approach was found to have shorter postoperative hospitalization compared to LE (GM 0.78, 95% CI 0.64–0.93, p = 0.0073) and open intervention (GM 0.78, 95% CI 0.66–0.93, p = 0.0067). Multivariate analysis determined no significant difference in direct cost for LI approach compared to LE (GM 0.78, 95% CI 0.85–1.14, p = 0.86) and open technique (GM 1.02, 95% CI 0.88–1.19, p = 0.76) (Table 4).

Discussion

Our study featured a review of consecutive cases of loop ileostomy reversal from February 2013 to June 2016 by colorectal surgeons at a single high-volume institution, examining the implementation of laparoscopic intracorporeal stoma reversal. Our findings demonstrated that LI was associated with a significantly reduction in LOS when compared to LE and open approaches. Similar postoperative morbidity rates, total cost, and direct cost were noted among all three surgical techniques. Our findings indicate that laparoscopic loop ileostomy reversal with intracorporeal anastomosis is a safe, feasible technique with acceptable outcomes.

Fecal diversion by means of a loop ileostomy continues to be selectively performed for high-risk colorectal anastomoses but carries notable risk [18]. Ileostomy reversal has previously been associated with an overall morbidity rate of 17.3–21.5% and mortality of 0.4% [19]. In a review of the literature, following both open and laparoscopic loop ileostomy reversal, Kaidar-Person et al. reported a 0–15% rate of small bowel obstruction, 0–18.3% rate of wound infection, and 0–8% rate of anastomotic leak [20]. These findings emphasize the need to develop more effective surgical methods for reversal.

Prior studies have documented initial experience with laparoscopic loop ileostomy reversal. Through a randomized clinical trial of 74 patients, Royd et al. examined the addition of laparoscopy following standard open loop ileostomy reversal and demonstrated reduction in median length of stay, postoperative morbidity, and median cost [21]. However, it is important to note that Royd et al. did not perform an intracorporeal anastomosis in their laparoscopic study arm, as they simply inserted a laparoscope after open ileostomy closure and lysed adhesions. They hypothesized that early return of bowel function was facilitated by laparoscopic lysis of adhesions. Russek et al. retrospectively examined utilization of laparoscopic extracorporeal loop ileostomy reversal in 24 patients with comparable complication rates and operative duration to open reversal [22]. In this study, no patients underwent intracorporeal anastomosis; laparoscopy was used to perform enterolysis prior to extracorporeal anastomosis and to facilitate an intracorporeal mesh placement. In a retrospective review of 133 cases between June 2009 and August 2013, Young et al. compared open and laparoscopic loop ileostomy reversal, demonstrating similar estimated blood loss, mean length of stay, and 30-day morbidity rates; however, cost was not evaluated. Operative duration was longer with laparoscopic reversal but this was associated with higher rates of adhesiolysis. Intracorporeal anastomosis was only utilized in 11 patients and no subset analysis of this group was performed [23]. All three techniques were well tolerated with no statistical difference in risk-adjusted postoperative in-hospital morbidity rates.

In comparison, our study includes the largest cohort of ileostomy reversal patients who had an intracorporeal anastomosis and is the first study evaluating comparative costs of intracorporeal anastomosis technique. Our study has illustrated a reduction in postoperative hospitalization length of stay for laparoscopic intracorporeal reversal when compared to both open and extracorporeal approaches. Mari et al. have demonstrated an association between intracorporeal approach and reduction in the surgical stress response which clinically manifests as earlier gastrointestinal recovery [24]. This effect may be secondary to reduction in bowel manipulation during intracorporeal anastomosis; in contrast, both open and extracorporeal technique require exteriorization which may render undue stress on enteric tissue and the mesentery. Grams et al. have illustrated this physiological benefit of intracorporeal anastomosis in laparoscopic right colectomy as well, as evidenced by earlier return of flatus, reduction in narcotic use, and shorter length of stay [25]. Ileostomy exteriorization may be further challenging in obese patients with increased abdominal wall thickness. As reflected by the overweight BMI distribution (24.4–26.4 kg/m^2) of our three cohorts, intracorporeal technique may ultimately be a more technically feasible option for this population type.

Our risk-adjusted analysis of direct and total costs demonstrated no significant difference among the three techniques. Despite the significant reduction in length of stay for intracorporeal reversal, we believe these reductions of in-hospital cost are likely off-set by increased operative expenses, given the prolonged operative duration associated with laparoscopic procedures as well as increased expenditure for laparoscopic devices such as endo-GIA stapler cartridges. Assessment of heath care expenditure over a more prolonged duration may demonstrate cost divergence among the three techniques given the propensity for late-onset complications outside the window of our current study. In an examination of heath utilization costs for laparoscopic and open colectomy, Crawshaw et al. demonstrated that even at 90 days and 1 year from intervention, minimally invasive colectomy was associated with significant reductions in health care expenditure [26].

The antecedent operation for laparoscopic intracorporeal cases was more commonly either a laparoscopic or robotic intervention. These findings primarily reflect the increased implementation of minimally invasive techniques over the course of our study period. It also has previously been described that ileostomy closure following minimally invasive index operations is associated with fewer complications and shorter operative duration due to reduced intra-abdominal adhesions [27]. In contrast, shorter length of stay was associated with intracorporeal closure despite statistically equivalent rates of adhesiolysis among the three techniques. This ultimately suggests similar operative environments for the three cohorts and offers further validity to the benefit of intracorporeal technique.

Limitations were noted in our study. Inherent biases related to a retrospective study design are present. All patients were principally treated under the same enhanced recovery protocol which was equivalent over the study period but subject to changes in the treatment and pain control regimen as determined by the primary surgeon. In our review of sequential cases, laparoscopic intracorporeal reversal was increasingly implemented over our study period, reflecting growing familiarity and comfort with this operative technique towards the end of our study period. This suggests that further prospective analysis may demonstrate additional differences in outcomes among these three operative methods.

In conclusion, laparoscopic loop ileostomy reversal with intracorporeal anastomosis is a safe, feasible operation with a reduction in length of stay and similar morbidity and cost as extracorporeal and open reversal techniques. These findings are especially pertinent to the overweight and obese patient population for whom open exteriorization and extra-corporeal reversal may prove to be challenging. Our study encourages the development of further clinical trials to assess the role of this technique.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Disclosures

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Table 1

Patient characteristics

	LI *N* **= 33**	**LE** *N* **= 49**	**Open** *N* **= 50**
Mean age ± SD (years)	51.4 ± 15.0	56.8 ± 13.8	51.0 ± 14.3
Median age (IQR) (years)	51 (42–64)	56 (49–66)	55 (43–61)
Gender			
Male (%)	42	61	50
Female (%)	58	39	50
Ethnicity			
Caucasian	79	65	64
Black	3	2	2
Asian	3	8.2	4
Other	15	24	30
Mean BMI ± SD (kg/m^2)	26.4 ± 4.6	25.4 ± 5.2	24.4 ± 4.4

LI is used as baseline for comparison

No statistically significant differences were noted for patient characteristics among the three groups

LI laparoscopic intracorporeal, *LE* laparoscopic extracorporeal, *SD* standard deviation, *IQR* interquartile range

Table 2

Patient comorbidities and operative characteristics

	LI *N* = 33	LE *N* = 49	Open *N* = 50
Cardiovascular (%)			
HTN requiring medication	27.3	34.7	30
Congestive heart failure	6.1	0	0
Pulmonary (%)			
Dyspnea	0	2	2
COPD	0	2	4
Current tobacco use	3	8.2	8
Renal (%)			
Dialysis	0	0	0
Preoperative acute kidney injury	0	0	0
Hepatic (%)			
Ascites	0	0	0
Endocrine (%)			
Diabetes mellitus	18.2	14.3	7
Steroid use	0	2	4
Hematologic/oncologic (%)			
Disseminated cancer	3	6.1	8
Chemotherapy with 90 days	30.3	34.7	24
Bleeding disorder	3	0	0
Functional status (%)			
Independent	94	96	100
Partially dependent	6.1	4.1	0
Antecedent surgery approach (%)			
Open	9.1	8.2	38 *
Laparoscopic	52	41	28 *
Laparoscopic/robotic	39	51	34
Antecedent indication (%)			
Colon cancer	6.1	6.1	8
Rectal cancer	64	65	38 *
Ulcerative colitis	15	12	30
Crohn’s disease	0	0	6
Diverticulitis	3	4.1	4
Other	12.1	12.2	14

LI is used as baseline for comparison

LI laparoscopic intracorporeal, *LE* laparoscopic extracorporeal, *COPD* chronic obstructive pulmonary disease

*p-value of < 0.05

Table 3

Analysis of operative outcomes

	LI **$N = 33$**	**LE** **$N = 49$**	**Open** **$N = 50$**
Mean length of stay ± SD (h)	60.4 ± 23.4	90.3 ± 91.5 *	81.8 ± 56.3 *
Median length of stay (IQR) (h)	52.1 (47.6–72.9)	69.6 (50.7–98.4)	69.0 (51.4–93.3)
Mean operative duration ± SD (min)	172.4 ± 42.2	157.6 ± 39.9 *	140.7 ± 47.1 *
Mean estimated blood loss ± SD (cc)	24.2 ± 20.7	25.7 ± 17.7	26.7 ± 32.4
Conversion to midline laparotomy (%)	0	2.04	8
Adhesiolysis (%)	54	69	56
30-day readmission (%)	9.1	2	6
30-day mortality (%)	0	0	0
30-day morbidity (%)	6.1	14.3	10
Stroke/CVA (%)	0	0	0
Acute coronary syndrome (%)	0	0	0
Pneumonia (%)	0	0	0
Ventilator dependency (%)	0	0	0
Pulmonary embolism (%)	0	0	0
Ileus (%)	0	8.16	2
Anastomotic Leak (%)	0	0	0
Postoperative bleeding (%)	0	2.04	4
Postoperative transfusion (%)	0	2.04	0
Surgical site infection (%)	0	0	0
Urinary retention (%)	6.06	4.08	4
Urinary tract infection (%)	0	0	0
Median total cost (IQR), $	10,761.00 (9934.50–12,901.50)	11,274.00 (9706.00–14,022.00)	10,386.00 (9127.00–13,855.00)
Median direct cost (IQR), $	6575.00 (5740.50–7920.00)	6,722.50 (5715.00–8635.00)	6181.00 (5459.00–8440.00)

LI is used as baseline for comparison

LI laparoscopic intracorporeal, *LE* laparoscopic extracorporeal, *SD* standard deviation, *IQR* interquartile range

* p-value of < 0.05.

CVA – cerebrovascular accident

Table 4

Multivariate analysis of operative outcomes

Length of hospital stay	GM/OR	95% CI	*p*-value	In-hospital total cost	GM/OR	95% CI	*p*-value
LI versus open	0.78	0.66–0.93	0.0067	LI versus open	1.02	0.88–1.18	0.83
LE versus open	1.01	0.84–1.22	0.893	LE versus open	1.03	0.89–1.19	0.65
LI versus LE	0.78	0.64–0.93	0.0073	LI versus LE	0.99	0.85–1.12	0.81
30-day morbidity	**GM/OR**	**95% CI**	***p*-value**	**In-hospital direct cost**	**GM/OR**	**95% CI**	***p*-value**
LI versus open	0.53	0.09–3.125	0.48	LI versus open	1.02	0.88–1.19	0.76
LE versus open	1.22	0.36–4.17	0.74	LE versus open	1.04	0.89–1.20	0.62
LI versus LE	0.43	0.081–2.33	0.33	LI versus LE	0.78	0.85–1.14	0.86

LI laparoscopic intracorporeal, *LE* laparoscopic extracorporeal