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Morbidity and mortality in patients undergoing fecal diversion as an adjunct to wound healing: a NSQIP comparison study

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Abstract

Background Fecal diversion for chronic, non-healing wounds improves quality of life, assists in wound healing, and helps to prepare for reconstructive surgery. While commonplace, little has been published regarding the safety of diversion in this patient subgroup. The purpose of this study is to elucidate the morbidity and mortality of fecal diversion for chronic wounds and to identify those patients with disproportionately high perioperative risk.

Methods Retrospective analyses were performed using the American College of Surgeons National Surgical Quality Improvement Project (NSQIP) database and an institutional database. The primary outcome analyzed was 30-day mortality and secondary outcomes included 30-day morbidity and readmission rate.

Results Eight hundred fifty-nine patients were identified in the NSQIP database who underwent diversion compared to 3990 who did not. In unmatched data, there were no significant differences in substantial 30-day morbidities. In matched data, diverted patients had a significantly lower perioperative mortality. Fifty-six patients were identified in the institutional review who were diverted for non-healing wounds. Fifty percent of patients with a preoperative ejection fraction of less than 30% died within 30 days of surgery (LR 6.58, $p = 0.045$).

Conclusions The NSQIP review indicates that fecal diversion does not inherently increase 30-day perioperative morbidity or mortality. While 30-day morbidity remains high, the institutional review suggests that patients with cardiac dysfunction contribute to the majority of complications. As such, an ejection fraction less than 30% may be a relative contraindication to immediate diversion. Medical optimization and elective diversion should be considered whenever feasible.

Level of Evidence: Level III, risk / prognostic study.

Keywords NSQIP · Decubitus wounds · Diversion · Stoma

Introduction

Stoma creation is routinely performed to achieve fecal diversion in the setting of chronic, non-healing wounds of the sacrum, ischium, and perineum [1–13]. Diverting stomas improve quality of life, assist in wound healing, and help prepare for reconstructive surgery [1–13]. While these procedures are commonplace, little is known about their safety. Only two studies have been published in the last 20 years, a time frame during which significant advancements in abdominal surgery have been made [1–13]. Thus, the safety of fecal diversion surgery as it is performed today is largely unknown.

Colostomy creation itself is considered a low-risk procedure; however, the patients that require fecal diversion as an adjunct to wound healing represent a complex and heterogenous demographic. Patients range from being otherwise healthy, with only a history of spinal cord injury (SCI), to elderly, chronically ill patients. Reported data is also limited by the fact that most studies examine the former demographic, which presumably represent the healthier cohort [1–9]. In reality, a significant portion of the patients diverted for wound healing are elderly and bedridden from critical illness and/or multiple, severe, ongoing comorbid disease states. As such, it is difficult to parse out the inherent risks of

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the procedure. Perioperative morbidity and mortality rates can be high and range from 0 to 44% and 0–15%, respectively. This data comes from retrospective institutional analyses with variable sample sizes [1–13]. The significant perioperative risk has called into question the futility of fecal diversion in this setting [4].

The purpose of this study is to review the data regarding fecal diversion in the setting of non-healing wounds at both a national and institutional level. Using these two datasets, we aim to compare factors contributing to perioperative morbidity, mortality, and 30-day readmission rates. By selecting patients based on indication for diversion, we hope to capture the entire spectrum of patients that comprise this population. We aim to elucidate the safety of fecal diversion in this group of patients and to identify the subset of patients with disproportionately high perioperative risk. Understanding the associated risks is paramount to the plastic and reconstructive surgeon when referring patients for diversion.

Materials and methods

Institutional review

A retrospective analysis was performed at Hahnemann University Hospital from March 2003 until January 2017. All data extraction and review was conducted with approval from and in accordance with the Institutional Review Board of Drexel University College of Medicine. Patient records were initially filtered by operative reports. All patients undergoing ostomy creation during the study time period were identified and reviewed. Those patients with preoperative diagnoses of chronic, non-healing wounds were selected based on International Classification of Disease, ninth revision (ICD-9) codes. Patients without chronic wounds were excluded. Comprehensive data analysis was performed by two separate reviewers. Primary outcomes included 30-day mortality, 30-day morbidity, and 30-day readmission. Secondary outcomes included long-term stoma-related complications, referral to a plastic surgeon, eventual colostomy reversal, and time until wound closure. Findings were analyzed using SPSS version 24 using the CrossTabs function (chi-square). Nonparametric data was evaluated with Mann-Whitney U or Kruskal-Wallis tests as appropriate. A p value of 0.05 was considered significant for all calculations.

NSQIP review

A retrospective analysis was performed using data from the American College of Surgeons (ACS) National Surgical Quality Improvement Project (NSQIP) general participant use data file (PUF) between January 1, 2005 and December 31, 2015. Patients were selected if their post-op diagnosis pertained to any ICD-9 code in the category of chronic ulcer of the skin. Patients were excluded if their age was less than 18 years, their ASA class was higher than 4 or unknown, or if they were labeled as an emergency case. Patients were considered to have undergone diversion if one of the CPT codes for ileostomy/jejunostomy or colostomy were present.

Continuous variables were evaluated with Levene's test to determine variance. ANOVA was used to evaluate means for variables with equal variance and Welch's ANOVA was used for heteroscedastic variables. A Mann-Whitney U test was run to determine if there were differences in medians between continuous variables where distributions were similar. Models were developed with multiple linear regression in a forward stepwise approach. Partial correlation coefficients and Kruskal-Wallis tests were used to confirm independence of continuous variables included in the regressions. The primary outcomes assessed were 30-day mortality. Secondary outcomes assessed included 30-day morbidities captured in the NSQIP data set. All data manipulation and analyses were done using SPSS version 24. Propensity score matching was performed using the R script dialogue, version 3.0.4, developed by Thoemmes. A p value of 0.05 was considered significant for all calculations.

Results

Institutional review

Fifty-seven patients met inclusion criteria, one was excluded as diversion was prophylactic. The remaining 56 patients with active wounds who underwent fecal diversion as an adjunct to wound healing were included and all relevant information is depicted in Table 1. Average length of stay was 42.14 days with a 24.4% readmission rate within 30 days of discharge. Indications for diversion were the presence of a non-healing decubitus ulcer in 93%. Thirty-one percent of patients were disabled from a SCI and 20% were bedbound from chronic illness or dementia. Fifty-four percent of patients had preoperative echocardiography demonstrating ejection fractions of 55% or greater, whereas 13% of patients had ejection fractions less than 30%. Thirty-day morbidity was 21% and included bowel perforation, deep space surgical site infection, bowel obstruction requiring surgical intervention, aspiration pneumonia requiring intubation, acute coronary syndrome, stoma retraction and prolapse, acute kidney injury requiring hemodialysis, postoperative gastrointestinal hemorrhage, and cardiac arrest with return of

Table 1 Selected results from institutional database review

Variable	Results (percentage, number of patients)
Avg. age at time of diversion	59.34 years
Sex	Male = 64% (36); Female = 36% (20)
Race	African American = 61% (34); Caucasian = 30% (17); Hispanic = 9% (5)
Past medical history	Hypertension = 59% (33); diabetes mellitus type II = 45% (25)
Past surgical history	Tracheostomy = 27% (15); Abdominopelvic = 21% (12); PEG = 21% (12)
Smoking status	Current/former = 52% (28); never = 48% (26)
Admission diagnosis; Avg. LOS	Sepsis = 32% (18); 42.14 days
Discharge disposition	Home = 22% (11); other = 78% (38)
Readmission within 30 days	24.4% (12)
Indication for diversion	Pressure ulcer = 93% (52); wound from necrotizing soft tissue infection = 7% (4)
Disabling condition	Spinal cord injury = 31% (17); bedbound NOS = 20% (11); cerebrovascular accident = 16% (9); critically ill = 13% (7); neurologic inflammatory disease = 7% (4); other = 7% (4); traumatic brain injury = 5% (3)
Functional status	Bedbound NOS = 52% (28); paraplegic = 30% (16); quadriplegic = 18% (10)
Wound location	Sacrum = 84% (47); Ischium = 27% (15); perineum = 7% (4); trochanter = 4% (2)
Wound stage	Stage IV = 58% (32); stage III = 38% (20); stage II = 2% (1)
Preoperative echocardiogram	EF 55–70% = 54% (21); EF 45–54% = 15% (6); EF 30–44% = 18% (7); EF < 30% = 13% (5)
Avg. preoperative albumin; prealbumin	2.12 g/dL; 8.32 mg/dL
Stoma type	Transverse loop = 39% (22); sigmoid end = 36% (20); sigmoid loop = 21% (12); transverse end = 4% (2)
Open vs. laparoscopic	Open = 54% (30); laparoscopic = 46% (26)
Concurrent surgery	Yes = 50% (28); no = 50% (28)
Complications within 30 days	No = 79% (44); yes = 21% (12)
Long-term stoma-related complications (> 30 days)	Yes = 8% (4); no = 92% (46)
30-say all-cause mortality	14% (6)
Length of follow-up	1.12 years
Referred to plastic surgeon	14% (8)
Colostomy reversed	7% (4)
Wound closed; Avg time until closure	52% (11); 210 days from stoma creation

PEG percutaneous endoscopic gastrostomy tube, *LOS* length of stay, *EF* ejection fraction. Discharge disposition as "other" included skilled nursing facility or any type of rehabilitation facility. Disabling condition as "bedbound" NOS included patients who were chronically ill with multiple comorbidities or suffering from dementia. Disabling condition as "neurologic inflammatory disease" included patients who suffered from multiple sclerosis, chronic inflammatory demyelinating polyneuropathy or spinal abscesses. Disabling condition listed as "other" included spina bifida, lower extremity fractures, cerebral palsy, and no disabling condition. Functional status listed as "bedbound NOS" included patients who did not have limb paralysis but were bed bound due to multiple chronic medical comorbid conditions

spontaneous circulation. Eight percent of patients experienced stoma-related complications beyond 30 days postoperatively, which included stoma retraction, prolapse and stoma-related obstruction requiring surgical intervention. Thirty-day all-cause mortality was 14%; six patients died from sepsis from colonic perforation, progressive sepsis from wound infection, and cardiac arrest due to aspiration. Average length of follow-up was 1.12 years

and 52% of patients ultimately achieved wound closure at an average of 210 days postoperatively (Table 1).

With regard to 30-day readmission, significant patient factors included being bedbound secondary to paraplegia and a history of peripheral vascular disease. Both laparoscopic and open colostomy procedures were significant, as was the presence of a transverse colostomy. Surgical indications, albumin and prealbumin levels, were not

significant predictors. With regard to 30-day morbidity, significant factors included being bedbound secondary to critical illness and a history of substance abuse. Surgical indications being decubitus ulcers and NSTI both reached significance, as did creation of a transverse end colostomy. Those patients with wounds localized to the sacrum also had a significantly higher 30-day morbidity. Albumin and prealbumin levels were not significant predictors. With regard to 30-day mortality, older patients were more likely to die. Significant patient factors included being bedbound for other reasons, a history of thyroid disease, a history of chronic obstructive pulmonary disease (COPD), and a preoperative ejection fraction of less than 30%. The only significant procedural factor was creation of a transverse end colostomy. Patients who had complications from surgery also had a higher 30-day mortality. Surgical indications, albumin and prealbumin levels, were not significant predictors (Table 2).

NSQIP review

After applying selection criteria, 4849 patients were selected with a pressure ulcer as their postoperative diagnosis, 859 of which underwent diversion and 3990 of which did not. Preoperative patient characteristics were

analyzed based on whether or not patients were diverted at their initial surgery and subsequent univariate analysis of odds ratios of risk of diversion was also conducted based on the same preoperative variables.

In unmatched data analysis, there were no significant differences in postoperative acute kidney injury, renal failure, stroke, need for cardiopulmonary resuscitation, myocardial infarction, transfusion, deep venous thrombosis, or mortality. Those diverted did have a significantly increased risk of postoperative pneumonia, need for re-intubation, pulmonary embolism, postoperative urinary tract infection, and postoperative sepsis (Table 3). Additionally, the calculated NSQIP morbidity score has a significantly higher median and mean for patients who were diverted, which indicates that the diverted patients had a more severe baseline level of illness preoperatively (Table 4).

Propensity score matching was conducted to account for the disparity in preoperative morbidity. The patients were matched with a 1:1 exact matching scheme based off of the NSQIP morbidity probability (Table 5). This yielded the best matched subsample with the lowest relative multivariate imbalance (0.358 before matching, 0.012 after matching) and a chi-squared statistic of an overall balance test of 0.011 with $p = 0.918$. There was

Table 2 Statistically significant factors contributing to readmission, morbidity, and mortality in the institutional review arm.

	Percentage of likeliness to experience event	Likelihood ratio	p value
30-day readmission			
Bedbound due to paraplegia	44	5.905	0.027
History of peripheral vascular disease	55.6	6.267	0.016
Open surgical procedure	6.67	8.851	0.007
Laparoscopic surgical procedure	38.5	8.851	0.007
Transverse loop colostomy	4.5	7.251	0.018
30-day morbidity			
Bedbound due to critical illness	57.1	5.018	0.032
History of substance abuse	100	6.443	0.043
Diversion for non-healing decubitus ulcer	17.3	5.778	0.028
Diversion for necrotizing soft tissue infection	75	5.778	0.028
Sacral location of decubitus ulcer	14.9	6.27	0.016
Transverse end colostomy	100	6.443	0.043
30-day mortality			
Median age 79.5 years vs. 58.5 years	N/A	N/A	0.009
COPD	50	5.480	0.029
Ejection fraction < 30%	50	6.580	0.045
Thyroid disease	75	8.961	0.007
Transverse end colostomy	100	8.443	0.017
Surgical complications	33.3	4.478	0.046

N/A not applicable, *COPD* chronic obstructive pulmonary disease

Table 3 NSQIP review arm postoperative complications, unmatched data

	Categorical					Odds ratios (univariate)			
	Diverted		Not diverted			Diverted			
	$N = 859$	17.7%	$N = 3990$	82.3%	Chi-squared	Risk	Lower CI	Upper CI	
Postoperative PNA	49	5.7%	123	3.1%	0	1.902	1.354	2.671	*
Postoperative re-intubation	40	4.7%	73	1.8%	0	2.621	1.769	3.882	*
Postoperative sepsis	97	11.3%	348	8.7%	0.018	1.332	1.05	1.691	*
Postoperative septic shock	46	5.4%	109	2.7%	0	2.015	1.416	2.867	*
Return to OR	150	17.5%	413	10.4%	0	1.832	1.495	2.245	*
Pulmonary embolism	8	0.9%	10	0.3%	0.003	3.741	1.472	9.508	*
Postoperative UTI	73	8.5%	223	5.6%	0.001	1.569	1.191	2.066	*
Postoperative AKI	9	1.0%	28	0.7%	0.29	1.498	0.704	3.187	NS
Postoperative renal failure	5	0.6%	17	0.4%	0.537	1.368	0.503	3.719	NS
Postoperative stroke	3	0.3%	9	0.2%	0.508	1.55	0.419	5.738	NS
Postoperative CPR	15	1.7%	46	1.2%	0.157	1.524	0.847	2.742	NS
Postoperative MI	2	0.2%	12	0.3%	0.736	0.774	0.173	3.463	NS
Postoperative transfusion	71	8.3%	410	10.3%	0.074	0.787	0.605	1.024	NS
Postoperative DVT	17	2.0%	51	1.3%	0.113	1.559	0.896	2.713	NS
Death	57	6.6%	217	5.4%	0.169	1.235	0.914	1.67	NS

SSI surgical site infection, *PNA* pneumonia, *AKI* acute kidney injury, *UTI* urinary tract infection, *CPR* cardiopulmonary resuscitation, *MI* myocardial infarction, *DVT* deep venous thrombosis, *CI* confidence interval, *NS* not significant. *Significantly increased risk in the diverted cohort

no improvement in relative multivariate imbalance when using 1:2 exact matching or when considering NSQIP mortality probability as well. In matched data, diverted patients were significantly less likely to be discharged to home, develop a UTI, or require a transfusion. Diverted patients also had a lower perioperative mortality which was statistically significant ($p = 0.007$). Odds ratios additionally demonstrated a significantly lower need for transfusion and a lower mortality in the diverted group. The diverted group did have higher odds of developing a postoperative UTI, returning to the operating room and ultimately had a longer length of stay. There were no significant differences in the remainder of the variables (Table 6).

Discussion

Every year roughly 2.5 million patients develop decubitus wounds [14], costing the US health system 9–11 billion dollars [15]. As such, efforts to maximize patient care and minimize the financial burden of such wounds are critical. Optimal surgical management requires a multidisciplinary approach that involves the plastic, general, and colorectal surgeon. Factors predisposing to such wounds include SCI, disabling cerebrovascular accidents, cerebral anoxic incidents, critical illness, neurologic inflammatory diseases, and traumatic brain

injuries among many others [1–13]. In the urban hospital setting, SCI, particularly that of traumatic origin is a significant contributor to para- and quadriplegic states and subsequent refractory decubitus wound formation [5, 7].

In the presence of wounds stage II and above, or severe soft tissue wounds resulting from necrotizing perineal infections, maintaining a healthy wound bed is critical in preventing wound progression and florid sepsis [7]. This is often difficult given the proximity of most wounds to the anus. Concomitant bowel dysfunction has a very high incidence in this patient group and serves as a source of distress in addition to complicating wound management [5]. These patients frequently suffer from fecal impaction, fecal incontinence, hemorrhoids, anal fissures, and rectal prolapse, all of which have been shown to be associated with a reduced quality of life and feelings depressed self-worth [5, 16]. All of these physical and psychological complications have been shown to worsen over the course of time [6, 17].

Proponents for diversion of the fecal stream in these patients argue that stoma creation alleviates many of these factors. In particular, it creates a more manageable and hygienic wound bed [7]. It has additionally been shown to alleviate chronic constipation, incontinence and the need for complex, time-consuming bowel regimens [2, 3, 5, 6, 18]. Studies have also shown reduced hospital readmissions from gastrointestinal problems [19], an improved sense of patient independence [20] and multiple authors have demonstrated an overall increased quality of life for such patients [1, 5, 18, 20, 21]. De

Table 4 NSQIP review arm preoperative laboratory values and perioperative data

	Mann-Whitney U			ANOVA		
	Not diverted $N = 3990$	Diverted $N = 859$	p value	Not diverted $N = 3990$	Diverted $N = 859$	p value
NSQIP morbidity probability	0.1299	0.2274	0	0.1603	0.2578	0
NSQIP mortality probability	0.0147	0.0254	0	0.0482	0.0643	0
Operative time	39	77	0	63.88	89.36	0
Length of stay	8	16	0	13.32	22.39	0

la Fuente et al. have also demonstrated improvements in wound healing [7] and in certain institutions, fecal diversion is a prerequisite for complex flap-based reconstruction of decubitus wounds [4]. Those who advocate against fecal diversion for these patients are concerned with the high rate of morbidity and mortality and question the utility of diversion given the poor rates of wound healing [4, 6, 22]. Identifying the subgroup of patients who benefit from diversion is therefore paramount.

A review of the existing literature identified nine studies that evaluated patients who were diverted in the setting of chronic wounds. All published studies included only patients debilitated by SCI. Patients diverted purely for bowel dysfunction were not reviewed as the authors believe patients with refractory non-healing wounds from immobility represent a separate population. Said patients most likely have been debilitated for a longer period of time, are sicker on average, and have an elevated baseline mortality risk [23]. Reported morbidities and mortalities ranged from 0 to 43.75% and from 0 to 15% respectively. The morbidity and mortality in our study was 21% and 14% respectively, which is comparable and including those debilitated for reasons other than SCI likely increased the preoperative severity of illness in our cohort, which is supported by the NSQIP preoperative morbidity scores. Prior studies were unable to identify any specific patient factors that contributed to morbidity and mortality [1–9]. Several advocate for diversion given the benefits of increased self-worth decreased time required for bowel care and one study demonstrated a statistically significant decrease in decubitus wound recurrence and shortening of time to heal [7] (Table 7).

The NSQIP arm of this study compared 859 patients who underwent fecal diversion for chronic wounds to 3990 patients with chronic wounds who were not diverted. No significant difference was found in 30-day mortality which strongly suggests that fecal diversion does not present an immediate perioperative risk when compared to non-diverted patients in similar health. This is further supported by the lack of significant differences between the two groups with regard to substantial perioperative morbidities. Given the limitations of the NSQIP database, specifically the lack of follow-up beyond 30 days and the lack of subjective wound description, the information gathered cannot support any conclusions as to whether or fecal diversion improves wound healing. The institutional review analyzed 56 patients who underwent fecal diversion for chronic, non-healing wounds. Thirty-day morbidity and mortality rates were 21% and 14% respectively and these patients were likely sicker preoperatively, given the fact that not only SCI patients were included in this study. Thirty-day readmission rate was 24.4% and subset analysis did not reveal any modifiable risk factors. Risk factors for 30-day morbidity included being bedbound secondary to critical illness, which should prompt attempts to divert these patients in an elective fashion. Elective diversion may abbreviate morbidity by allowing the patient to recover from their admitting illness prior to surgery. With regard to 30-day mortality, elderly patients and those with a severely depressed ejection fraction appear to be at significantly elevated risk and such factors should prompt the physician to seriously weigh the risks and benefits of diversion. Of the patients who subscribed to routine follow-up, 52% were able to achieve wound closure, which is fairly high in this population. Further studies should be conducted to determine whether or not diversion improves and/or decreases time to wound healing.

Table 5 NSQIP review arm perioperative variables, matched data

	Mann-Whitney U analysis			ANOVA		
	Not diverted median	Diverted median	p value	Not diverted mean	Diverted mean	p value
NSQIP morbidity probability	0.2274	0.2267	0.962	0.2578	0.2572	0.918
NSQIP mortality probability	0.0254	0.0454	0	0.0643	0.0873	0
Operative time	77	41	0	89.36	65.83	0
Length of stay	16	10	0	22.39	15.28	0

Table 6 NSQIP review arm postoperative complications, matched data

	Categorical					Odds ratios (univariate)			
	Diverted		Not diverted			Diverted			
	N = 859		N = 859		Chi-squared	Risk	Lower CI	Upper CI	
Return to OR	150	17.5%	106	12.30%	0.003	1.503	1.148	1.967	*
Postoperative UTI	73	8.5%	45	5.20%	0.008	1.68	1.144	2.467	*
Postoperative PNA	49	5.7%	45	5.20%	0.671	1.094	0.722	1.659	NS
Postoperative re-intubation	40	4.7%	31	3.60%	0.275	1.305	0.808	2.106	NS
Pulmonary embolism	8	0.9%	6	0.70%	0.591	1.336	0.462	3.868	NS
Postoperative AKI	9	1.0%	6	0.70%	0.437	1.505	0.533	4.248	NS
Postoperative renal failure	5	0.6%	12	1.40%	0.088	0.413	0.145	1.178	NS
Postoperative stroke	3	0.3%	1	0.10%	0.317	3.007	0.312	28.965	NS
Postoperative CPR	15	1.7%	23	2.70%	0.189	0.646	0.335	1.247	NS
Postoperative MI	2	0.2%	2	0.20%	1	1	0.141	7.115	NS
Postoperative DVT	17	2.0%	12	1.40%	0.349	1.425	0.676	3.002	NS
Postoperative sepsis	97	11.3%	85	9.90%	0.347	1.159	0.852	1.577	NS
Postoperative septic shock	46	5.4%	45	5.20%	0.914	1.023	0.671	1.561	NS
Postoperative transfusion	71	8.3%	125	14.60%	0	0.529	0.389	0.72	†
Death	57	6.6%	88	10.20%	0.007	0.623	0.44	0.882	†

SSI surgical site infection, *PNA* pneumonia, *AKI* acute kidney injury, *UTI* urinary tract infection, *CPR* cardiopulmonary resuscitation, *MI* myocardial infarction, *DVT* deep venous thrombosis, *CI* confidence interval, *NS* not significant. *Significantly increased risk in diverted cohort; † Significantly decreased risk in diverted cohort

Limitations of the institutional review include the inherent bias of retrospective analysis. This was a single-institution analysis and there was no comparison to a control group that did not undergo fecal diversion. In addition, these patients frequently attend multiple emergency departments within the region and are frequently lost to follow-up. One of the surgeons operated through a private practice and, as such, his follow-up information was not available.

Limitations of the NSQIP arm included the limited 30-day postoperative follow-up, and the lack of patient tracking as there is a new entry for each initial surgical procedure. This is reflected in the inability to determine how many times that specific patient has been debrided. It was also unable to determine which procedures were performed laparoscopically vs. open outside of specific CPT codes, which do not exist for this study.

Table 7 Literature review for all published studies examining fecal diversion in debilitated patients

Study	Number of patients undergoing fecal diversion	Indication for diversion	Morbidity	Mortality
Frisbie et al. [1]	20	Various	NR	NR
Stone et al. [2]	20	Various	15%	0%
Saltzstein and Romano [3]	16	Various	0%	0%
Deshmukh et al. [4]	27	Non-healing wounds	30.43%	15%
Craven and Etchells [5]	19	Various	NR	NR
Branagan et al. [6]	35	Various	43.75%	8.6%
de la Fuente et al. [7]	41	Non-healing wounds	9.7%	2.44%
Munck et al. [8]	23	Various	26%	0%
Ratnasekera et al. [9]	66	Non-healing wounds	31.8%	NR
This study	56	Non-healing wounds	21%	14%

NR not reported. Indication for diversion listed as "various" generally includes a combination of non-healing wounds and bowel dysfunction. "Bowel dysfunction" refers to incontinence and/or intractable constipation

Conclusion

Fecal diversion for bedridden patients is important to consider for a variety of reasons, and in many institutions, control of the fecal stream is a prerequisite for reconstructive plastic surgery. While it remains unclear if diversion itself improves wound healing, it undoubtedly simplifies wound care which should decrease rates of wound infection, subsequent hospital admissions, and the need for repeated debridement. It is therefore of critical importance to the surgeon to understand the true risks of this procedure. This study suggests that complication rates are high within this patient subgroup; however, fecal diversion in itself does not inherently increase morbidity or mortality in patients with chronic wounds. Elderly patients and/or those with a preoperative ejection fraction less than 30% are at a disproportionately higher risk of death within the first 30 days postoperatively and clinicians should have a low threshold for preoperative echocardiography. Ejection fractions of less than 30% may be a relative contraindication to immediate fecal diversion in the absence of medical optimization and diversion in the elective setting should be considered whenever possible. Optimal patient selection is paramount to the success of this operation and even the sickest patients can be safely diverted prior to complex decubitus wound reconstruction.

Compliance with ethical standards

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