International Journal of Colorectal Disease (2019) 34:1227–1232
https://doi.org/10.1007/s00384-019-03319-w

ORIGINAL ARTICLE

Omental flaps in patients undergoing abdominoperineal resection for rectal cancer

Vanessa M. Welten[1] · Adam C. Fields[1] · Pamela Lu[1] · Joel E. Goldberg[1] · Jennifer Irani[1] · Ronald Bleday[1] · Nelya Melnitchouk[1]

Accepted: 17 May 2019 / Published online: 23 May 2019

Abstract

Background Following abdominoperineal resection (APR) for rectal cancer, perineal wound complications are common. Omental flap creation may allow for decreased morbidity. The aim of this study was to assess wound complications in rectal cancer patients undergoing APR with and without the addition of an omental flap.

Methods The National Surgical Quality Improvement Program Proctectomy targeted database from 2016 to 2017 was used to identify all patients undergoing APR for rectal cancer. The primary outcomes were wound complications such as superficial site infection, deep wound infection, organ space infection, and wound dehiscence.

Results There were 3063 patients identified. One hundred seventy-three (5.6%) patients underwent APR with an omental flap repair while 2890 (94.4%) patients underwent APR without an omental flap repair. Patients in both groups were similar with regard to age, gender, body mass index, American Society of Anesthesia class, and neoadjuvant cancer treatment (all $p > 0.05$). Patients who underwent an omental flap repair were significantly more likely to have a postoperative organ space infection (10.4% vs. 6.5%, $p = 0.04$). There was no significant difference in rates of superficial site infection, deep wound infection, wound dehiscence, or reoperation between the two patient groups. In multivariable analysis, omental flap creation was independently associated with organ space infection (OR 1.72, 95%CI 1.02–2.90, $p = 0.04$).

Conclusions This is the largest study to evaluate omental flap use in rectal cancer patients undergoing APR. Omental flaps are independently associated with organ space infection.

Keywords Rectal cancer · Omental flap · Postoperative infection

Introduction

Perineal wound complications following abdominoperineal resection (APR) for rectal cancer are common, with rates reported to be as high as 40–60% [1–8]. These wound complications include superficial and deep infections, wound dehiscence, and delayed wound healing. Wound complications following APR are associated with higher rates of readmission, reoperation, local tumor recurrence, and mortality [2, 6, 9, 10].

There are multiple known risk factors associated with wound complications following APR for rectal cancer, which include older age, increased body mass index (BMI), malnutrition, cigarette smoking, alcohol intake, history of inflammatory bowel disease, and neoadjuvant chemoradiotherapy [1–3, 6, 8, 11, 12]. Risk factors aside, the high propensity toward wound complications following APR is thought to be related to anatomic factors specific to the operation, including the large non-collapsible dead space remaining following pelvic resection, poorly vascularized tissue in cases of preoperative radiation, as well as high bacterial colonization [1, 2, 4, 7, 13, 14].

The aim of this study was to assess wound complications following APR with and without the addition of an omental flap repair utilizing the American College of Surgeon's National Surgical Quality Improvement Program (ACS NSQIP), a national, multicenter database.

Vanessa M. Welten and Adam C. Fields are co-first authors

✉ Vanessa M. Welten
vwelten@partners.org

✉ Nelya Melnitchouk
nmelnitchouk@bwh.harvard.edu

[1] Department of Surgery, Division of Colorectal Surgery, Brigham and Women's Hospital, Harvard Medical School, 75 Francis Street, Boston, MA 02115, USA

Materials and methods

Data source and patient selection

The ACS NSQIP database is a validated, risk-adjusted, prospectively collected national database that collects information on patient demographics, comorbidities, operative outcomes, for quality, and safety purposes [15]. Additional information regarding design and statistical methodology of the ACS NSQIP database is published elsewhere [16]. For this study, the ACS NSQIP Proctectomy targeted database was queried from 2016 to 2017 to identify patients undergoing APR for rectal cancer [17]. Patients who underwent reconstruction with myocutaneous flap were excluded. Patients undergoing APR for indications other than rectal cancer were also excluded. The current study was reviewed and exempt by the Institutional Review Board at Brigham and Women's Hospital.

Variables and outcomes

The NSQIP database was utilized to obtain patient demographics and comorbidities, as well as preoperative, operative, and postoperative variables. Patient demographic variables included age, gender, BMI, and race. Comorbidities assessed for each patient included diabetes, hypertension (HTN), history of cigarette smoking, preoperative steroid use, as well as preoperative weight loss. Preoperative albumin was recorded to assess the patients' nutritional status. Operative variables related to the APR procedure recorded and included minimally invasive versus open procedure, wound classification, as well as American Society of Anesthesiology (ASA) physical classification. Additionally, cancer treatment with neoadjuvant chemotherapy or radiotherapy, location of the tumor within the rectum (lower third, middle third, or upper third), as well as margin status were recorded for each patient.

Postoperative complications were recorded and analyzed. The primary outcomes were perineal wound complications including superficial infection, deep wound infection, organ space infection, and dehiscence. Secondary outcomes included incidence of ileus and reoperation rates. All complications recorded occurred within 30 days of the initial procedure, as the NSQIP database collects information on postoperative complications within 30 days of surgery.

Statistical analysis

Patient demographics, preoperative, operative, and postoperative variables were compared between the omental flap and the no flap group using descriptive statistics. Fisher's exact test was used to compare categorical variables, and results are expressed as percentages for Table 1. Wilcoxon rank sum tests were carried out to compare continuous variables and are expressed as medians and interquartile ranges. There is inherent selection bias when choosing to perform an omental flap repair. In order to control or inherent differences between the two patient groups, we calculated propensity scores to reduce this selection bias. We used a propensity score-adjusted logistic regression. Propensity scores were generated by performing a binary logistic regression with omental flap repair as the dependent variable and Table 1 predictors as covariates. Our propensity score is the probability of a patient undergoing an omental flap repair based on Table 1 factors. After propensity score adjustment, no factors in Table 1 remained statistically significant, showing an elimination of selection bias between the two patient groups. Multivariable logistic regression of risk factors associated with postoperative complications was then carried out using dependent variables significant in univariate analysis and the propensity score. Dependent variables were deemed significant if they were found to have a $p < 0.10$ in the univariable analysis. For all statistical analyses, two-sided p values were utilized and a p value < 0.05 was chosen as denoting a statistically significant difference. SPSS software version 22 (Chicago, IL) was used to perform all statistical analyses.

Results

Patient characteristics

A total of 3063 patients were identified who underwent APR for rectal cancer (Fig. 1). Of these patients, 173 (5.6%) underwent APR with omental flap repair, while 2890 (94.4%) underwent APR without an omental flap repair. Table 1 summarizes the patient characteristics, including demographics, comorbidities, procedure characteristics, preoperative labs, as well as treatment and tumor characteristics. Prior to propensity score adjustment, there was only one patient characteristic that was significantly different between the two patient groups; patients in the no flap group were more likely to have undergone a laparoscopic APR ($p < 0.001$). There was no significant difference in patient age, gender, and BMI between the omental flap and the no flap repair groups (all $p > 0.05$). Patients in both groups were similar with regard to comorbidities. There was no statistical difference in ASA class or wound class between the two groups (all $p > 0.05$). There was no difference in neoadjuvant chemotherapy ($p = 0.14$) or radiotherapy ($p = 0.26$) between the two groups. For tumor characteristics, there was no significant difference in the location of tumor ($p = 0.08$) or margin status between the two groups ($p = 0.75$). After adjustment with propensity scores, no patient characteristics remained statistically significantly different between the patient groups.

Table 1 Patient characteristics

	Omental flap ($N = 173$)	No flap ($N = 2890$)	*P* values	
			Unadjusted	Propensity score adjusted
Demographics				
Age, y	61.0 (53.0–69.0)	62 (53.0–71.0)	0.75	0.70
Female	73 (41.2%)	1088 (37.7%)	0.23	0.21
BMI (kg/m^2)	27.5 (24.8–31.8)	27.1 (23.6–31.3)	0.35	0.40
Race			0.21	0.30
White	149 (90.2%)	1989 (85.3%)		
Black	16 (8.8%)	151 (6.3%)		
Comorbidities				
Diabetes	28 (18.6%)	441 (14.7%)	0.74	0.94
HTN	84 (49.5%)	1197 (40.9%)	0.07	0.89
Smoker	27 (17.2%)	517 (17.8%)	0.45	0.89
Steroid use	8 (4.9%)	96 (3.5%)	0.36	0.28
Weight loss	13 (8.3%)	186 (6.3%)	0.58	0.60
Procedure characteristics				
Minimally invasive	39 (23.0%)	1596 (55.3%)	< 0.001	0.12
Wound class 3/4	30 (18.6%)	469 (16.5%)	0.70	0.71
ASA class 3/4	114 (67.6%)	1811 (63.2%)	0.40	0.89
Preoperative labs				
Albumin (g/dL)	3.9 (3.6–4.2)	4.0 (3.7–4.3)	0.34	0.07
Tumor characteristics				
Neoadjuvant chemotherapy	104 (58.2%)	1568 (53.5%)	0.14	0.09
Neoadjuvant radiotherapy	98 (53.2%)	1503 (51.0%)	0.26	0.15
Location of tumor			0.08	0.05
Lower/middle third	139 (80.3%)	2410 (83.3%)		
Upper third	10 (5.8%)	310 (10.7%)		
Positive margins	13 (8.3%)	199 (6.8%)	0.75	0.88

Univariable analysis: postoperative outcomes

The incidence among all patients of postoperative wound infection were 4.7%, 1.2%, and 6.7% for superficial infection, deep wound infection, and organ space infection, respectively (Table 2). There was no significant difference in the incidence of superficial or deep wound infection, between the omental flap and the no flap groups, but patients who underwent an

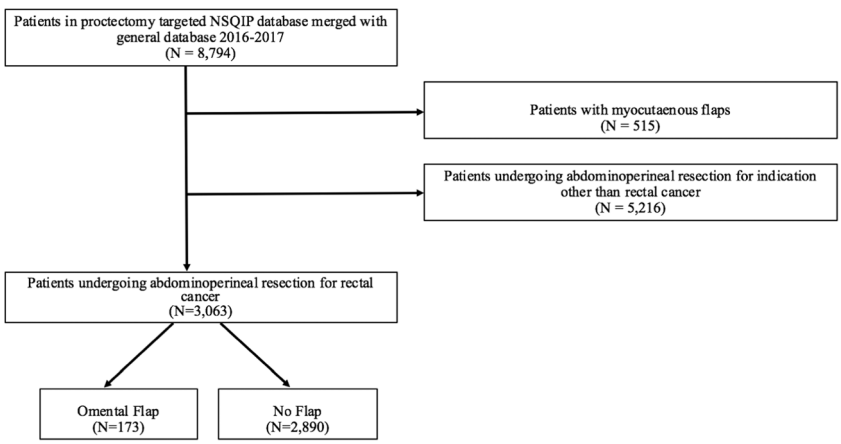

Fig. 1 Patient Selection

Table 2 Postoperative outcomes

	Omental flap ($N = 173$)	No flap ($N = 2890$)	p value
Superficial infection	9 (5.2%)	135 (4.7%)	0.71
Deep wound infection	2 (1.2%)	36 (1.2%)	1.00
Organ space infection	18 (10.4%)	187 (6.5%)	0.04
Dehiscence	5 (2.9%)	41 (1.4%)	0.12
Ileus	41 (23.7%)	576 (19.9%)	0.23
Reoperation	10 (5.8%)	158 (5.5%)	0.86

APR with omental flap repair were significantly more likely to have a postoperative organ space infection (10.4% vs. 6.5%, $p = 0.04$). The overall incidence of wound dehiscence was 1.5%, and there was no significant difference in the incidence of wound dehiscence between groups. The overall incidence of postoperative ileus was 20.1% and that of reoperation was 5.5%, with no significant difference between the two groups.

Multivariable analysis: risk factors for wound complications

In the multivariable analysis of risk factors for wound complications, omental flap repair was independently associated with organ space infection (OR 1.72, 95% CI 1.02–2.90, $p = 0.04$) (Table 3). Higher wound class (OR 1.21, 95% CI 1.02–1.44, $p = 0.03$), cigarette smoking (OR 1.62, 95% CI 1.16–2.26, $p = 0.01$), and diabetes (OR 1.45, 95% CI 1.01–2.07, $p = 0.04$) were also independent predictors of organ space infection. In the multivariable analysis of risk factors for wound dehiscence, cigarette smoking (OR 2.42, 95% CI 1.29–4.54, $p = 0.01$), and preoperative steroid use (OR 4.84, 95% CI 1.98–11.83, $p = 0.001$) were independent risk factors for wound dehiscence.

Table 3 Multivariable analysis of risk factors for wound dehiscence and organ space infection

Complication	Odds ratio	95% confidence interval	p value
Wound dehiscence			
Omental flap	1.75	0.63–4.60	0.26
Smoking	2.42	1.29–4.54	0.01
Steroid	4.84	1.98–11.83	0.001
Wound class	1.31	0.94–1.83	0.12
Organ space infection			
Omental flap	1.72	1.02–2.90	0.04
Wound class	1.21	1.02–1.44	0.03
Smoking	1.62	1.16–2.26	0.01
Diabetes	1.45	1.01–2.07	0.04

Discussion

Wound complications following APR are common and are associated with significant morbidity. They include superficial site infection, deep site infection, organ space infection, and wound dehiscence. The resection involved in APR leaves behind a large non-collapsible dead-space in which fluid and bacteria can easily collect [1, 2, 4, 7, 13, 14, 18]. Additionally, many patients undergoing APR have received neoadjuvant radiotherapy, worsening both the quality, and vascularity of the tissue, thereby making the wound more susceptible to infection [4, 19]. Given the high rates of wound complications following APR, omental flap creation is a surgical technique that was introduced to decrease the operation's associated morbidity by reducing the size of the remaining dead space with well-vascularized tissue [13, 18, 20–25]. However, studies assessing the benefit of pelvic reconstruction using omental flaps have produced mixed results. In 2013, a systematic review comparing primary repair to pelvic reconstruction with omentoplasty following APR found that omentoplasty increased the rate of perineal wound healing, decreased time to wound healing, and decreased the wound infection rate, while adding minimal additional operation time [23]. However, Blok et al. (2018) found no difference in wound healing or abscess formation comparing primary repair to omentoplasty [18]. A subsequent multicenter study by Blok et al. further compared primary repair with omentoplasty and found no difference in perineal wound healing rates between the two groups [13]. Moreover, a study of myocutaenous pelvic flap reconstruction recently demonstrated a higher rate of wound dehiscence in the flap closure group [26]. Given the mixed results of studies evaluating the effect of omental flap repair on wound complications following APR for rectal cancer, the aim of this study was to assess wound complications with and without the addition of an omental flap.

Our study is the largest contemporary evaluation of omental flap use in rectal cancer patients undergoing APR. This study demonstrates that omental flaps are associated with increased rates of organ space infection but not superficial wound infection, deep wound infection, or wound dehiscence.

In our study, the rate of organ space infection was 6.7%. This is in line with previous reports, where organ space infection rates following APR have been noted to range from 4 to 13% [2, 6, 13, 18, 26]. Our finding that omental flaps are associated with increased rates of organ space infection is also consistent with some prior reports but is in contrast to other published reports. A prospective multicenter center study as well as a systematic review, which both assessed omentoplasty following APR for cancer, suggested an improvement in perineal wound healing with omentoplasty, with the former study demonstrating a significantly higher rate of wound dehiscence in the no flap group [21, 25]. A subsequent systematic review evaluating omentoplasty following proctectomy for cancer found both decreased rate of infections and improved wound healing with omental flap repair [23]. However, recent studies found no difference in perineal wound healing and pelvic abscess for patients with and without omental closure [13, 18].

There are many factors thought to increase the risk of wound complications following APR, including older age, diabetes, obesity, poor nutritional status, smoking, alcohol, neoadjuvant chemotherapy, and radiation [1–3, 6, 8, 11, 12]. The current study demonstrated that cigarette smoking and preoperative steroids were independent predictors of wound dehiscence, while higher wound class, cigarette smoking, and diabetes were independent predictors of organ space infection. This is consistent with prior findings in the literature. While our study found that preoperative steroids use was associated with a higher risk of wound dehiscence, prior studies have found that steroid use was not associated with wound dehiscence, poor perineal wound healing, or perineal wound complications [1–3, 27]. A prior study by Rencuzogullari et al. using the ACS NSQIP database looking at predictors of wound dehiscence following APR identified use of muscle flap as significant independent risk factors for wound dehiscence, while use of omental flap was not [2]. Evidence is mixed regarding the risk of wound complications in patients who have undergone preoperative radiotherapy prior to APR. A few prior studies found that preoperative radiation therapy was not significantly associated with wound dehiscence, delayed wound healing, or wound complications [1, 2, 6, 11, 26]. Other studies, however, have demonstrated that preoperative radiotherapy is a risk factor for perineal wound complications, including delayed and poor wound healing, wound infections, wound dehiscence, and reoperation [3, 8, 12, 28]. The current study did not show an association between neoadjuvant radiotherapy and postoperative organ space infection following APR with or without omentoplasty. Similarly, results of studies assessing the association between neoadjuvant chemotherapy and perineal wound complications are also mixed, with some prior studies finding no association [2, 3, 6], while others identified preoperative chemotherapy as a risk factor for wound complications [1, 12]. Our study found no association between neoadjuvant chemotherapy and perineal wound complications post-APR.

It is unclear why omental flap closure might predispose to organ space infection. Dissection of the omental flap adds both time and complexity to the APR procedure [18]. The additional tissue handling involved in harvesting the omental flap may compromise the integrity of the flap's vasculature and increase the risk of postoperative infection [13]. A study of laparoscopic omental flap harvesting reported partial graft necrosis and vascular injury to the gastroepiploic artery and vein in 5.2% and 2.1% of cases, respectively [29]. A 2019 retrospective study comparing omental flap closure with primary healing following APR reported a 10% incidence of partial graft necrosis intraoperatively [13].

This study has some limitations. The results of the study are limited by a selection bias that exists regarding which patients ultimately undergo APR with omental flap closure versus primary repair; however, we have utilized propensity scores to eliminate this bias. Moreover, the retrospective design of the study limits the conclusions of this study, as it only demonstrates association and not causation. The study may also be subject to confounding due to the inability to measure certain unidentified factors that may impact the specific outcomes of interest. Though the ACS NSQIP database is extensive in the variables it presents, it does not collect certain information that may affect postoperative outcomes and the findings in this study, such as preoperative antibiotic use, or other details related to the surgical procedure or to surgical decision-making. The study is carried out in real populations and is not only limited to expert centers. Therefore, it is difficult to characterize the surgeons' experience utilizing omental flaps for pelvic reconstruction in APRs, particularly with a laparoscopic approach, and how the variability in expertise might impact postoperative outcomes compared with primary repair. Finally, the NSQIP database only collects postoperative complications within 30 days of surgery. The study also has many strengths. It is the largest study to evaluate omental flap use in rectal cancer patients undergoing APR. Additionally, the study utilized the ACS NSQIP database, which is a well-validated multicenter national database providing data that is applicable to multiple patient populations.

In conclusion, the current study utilizes the ACS NSQIP database to compare omental flap closure with no flap closure following APR for rectal cancer. Using contemporary data, we demonstrate that omental flap closure is independently associated with organ space infection. Further prospective investigation into the utility of omental flap closure following APR is needed, as results regarding its use remain mixed.

Author contributions All authors had substantial contributions to design of work, drafted work, made final approval, and agreed to be accountable for all aspects of the work.

Compliance with ethical standards

Disclosures None.

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