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Risk factors for wound dehiscence following radical cystectomy: a prediction model

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Abstract

Objectives: Radical cystectomy (RC) is a complex urologic procedure performed for the treatment of bladder cancer and causes significant morbidity. Wound dehiscence (WD) is a major complication associated with RC and is associated with multiple risk factors. The objectives of this study are to identify clinical risk factors for incidence of WD and develop a risk-prediction model to aid in patient risk-stratification and improvement of perioperative care.

Materials and Methods: The American College of Surgeons – National Surgical Quality Improvement Program (ACS-NSQIP) database was used to derive the study cohort. A univariate analysis provided nine variables eligible for multivariate model entry. A stepwise logistic regression analysis was conducted and refined considering clinical relevance of the variables, and then bootstrapped with 1000 samples, resulting in a five-factor model. Model performance and calibration were assessed by a receiver operated curve (ROC) analysis and the Hosmer–Lemeshow test for goodness of fit, respectively.

Results: A cohort of 11,703 patients was identified from years 2005 to 2017, with 342 (2.8%) incidences of WD within 30 days of operation. The final five-factor model included male gender [odds ratio (OR) = 2.5, $p < 0.001$], surgical site infection (OR = 6.3, $p < 0.001$), smoking (OR = 1.8, $p < 0.001$), chronic obstructive pulmonary disease (COPD) (OR = 1.9, $p < 0.001$), and weight class; morbidly obese patients had triple the odds of WD (OR = 2.9, $p < 0.001$). The ROC analysis provided a C-statistic of 0.76 and calibration R^2 was 0.99.

Conclusion: The study yields a statistically robust and clinically beneficial five-factor model for estimation of WD incidence risk following RC, with good performance and excellent calibration. These factors may assist in identifying high-risk patients, providing preoperative counseling and thus leading to improvement in perioperative care.

Keywords: cystectomy, postoperative complications, risk factors, statistical model, surgical wound dehiscence, urinary bladder neoplasms

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Introduction

Bladder cancer (BC) is the 10th most common cancer in the world and the 13th most deadly.[1] In the United States, it ranks as the sixth most common cancer overall and has caused 3% of all cancer-related mortalities up until 2020.[2] BC is divided into several subtypes; more than 90% are urothelial carcinomas, 5% are squamous cells, and less than 2% are adenocarcinomas.[3]

BC incidence is projected to significantly increase in the coming decade. By 2030, cases may exponentially rise in Germany (998%), France (191%), Bulgaria (129%), and Brazil (164%).[4] In addition to increasing incidence, the cost of bladder cancer management is also rising and is becoming a notable economic burden with increased adoption of bladder preservation strategies. The current average Medicare cost of

managing a single bladder cancer case is $78,276 over 6 years, a figure expected to rise in the coming years.[5]

Radical cystectomy (RC), with pelvic lymphadenectomy, is the current gold-standard surgical treatment for localized muscle-invasive bladder cancer and non-muscle-invasive urothelial tumors not responding to intravesical therapy.[6] RC is a relatively complex procedure and is associated with various complications and notable morbidity. Complications are reported using various postoperative complication grading systems, the most widely used in urologic surgery of which is the Clavien-Dindo classification system.[7] Complications of RC can be classified based on the organ system they involve with, the cardiac, renal and pulmonary complications being the most common and associated with the greatest odds of mortality in such patients.[8] Some of the common complications in specific include anemia, ileus, small bowel obstruction (SBO), urinary tract infection (UTI), sepsis, and arythmias.[7] Moreover, wound and stoma-related morbidities comprise a notable portion of all complications.[9] One of the most hazardous wound and stoma-related complications is wound dehiscence (WD), which is defined as the postoperative separation of a previously closed wound. Causes of WD are variable and include infection, mechanical separation, or poor wound healing related to vascular or metabolic insufficiencies.[10] WD incidence after RC ranges between 3.5% and 9%[11,12] and is associated with several risk factors such as male gender, history of chronic obstructive pulmonary disease (COPD), increase in body mass index (BMI), wound infection, azotemia, smoking, malnutrition, history of transient ischemic attack (TIA), blood transfusion, and prolonged operative time.[11,13–16] WD carries major clinical, psychological, and economic implications. In fact, the occurrence of WD was shown to be associated with increasing risk of evisceration, sepsis, readmission, reoperation, prolonged hospitalization, and overall mortality.[10,17–19]

Although individual associations between WD and several clinical factors have been established in previous studies, their effects have not been tested concurrently in a comprehensive risk model. Therefore, development of such a model could allow for improved patient selection, optimization of preoperative state, and postoperative management. As such, the aim of this study is to construct a clinically applicable and statistically robust risk-prediction model for WD following RC.

Methods

Patient population

The patient cohort was derived from the American College of Surgeons – National Surgical Quality Improvement Program (ACS-NSQIP) database years 2005–2017. The ACS-NSQIP is a de-identified, multicenter database that provides information on major surgical procedures performed at these centers located primarily in North America and other countries. The data include over 150 variables, encompassing patient demographics, laboratory values, medical comorbidities and conditions, intraoperative incidents, and comprehensive morbidity and mortality information up to 30 days postoperatively. Data are collected and entered directly into the ACS-NSQIP directory *via* certified surgical clinical reviewers. Periodic assessment of data quality is performed using interrater reliability (IRR) audits at participant centers. Surgical procedures are categorized with *Common Procedural Terminology* (CPT) codes. The following CPT codes, coding for different types of RC, were utilized to identify patients: 51570, 51575, 51580, 51585, 51590, 51595, and 51596.

Ethics approval

The de-identified database (ACS-NSQIP) does not constitute human subject research; therefore, no consent to participate was required. Moreover, no institutional review board approval was required or attained from the participating centers.

Clinical factors and primary outcome

All available data relating to patient demographic factors, medical conditions and comorbidities, laboratory results, and operative characteristics were analyzed. Patient demographic factors included age, sex, BMI classified using the Centers for Disease Control and Prevention (CDC) classification,[20] race, ethnicity, smoking status, and alcohol use. Medical conditions and comorbidities included history of diabetes mellitus, hypertension, COPD, congestive heart failure (CHF), hepatic disease, renal injury, chronic steroid use, and unintentional weight loss. Preoperative laboratory results included serum

creatinine (SCr), blood urea nitrogen (BUN), hematocrit (Hct), platelet count (Plt), and white blood cell count (WBC). Operative factors included the need for any preoperative blood transfusions and the American Society of Anesthesiologists (ASA) classification. The primary outcome was defined as the incidence of WD within 30 days of RC.

Statistical analysis and model construction

First, a descriptive analysis was performed using the independent *t* test for continuous variables and the chi-square (χ^2) test for categorical variables. All clinical variables were entered into a univariate logistic analysis to determine eligibility for the multivariate logistic regression. All variables with clinical significance and a univariate *p* value <0.05 were entered simultaneously into the multivariate analysis. Individual variables with loss of statistical significance were removed and model comparisons were performed, resulting in the final model. Assessment of model performance was done using a receiver operated curve (ROC) analysis, resulting in an ROC and concordance statistic (C-statistic). Moreover, calibration was tested using the Hosmer–Lemeshow test for goodness-of-fit contingency table and the coefficient of determination (R^2) was calculated. The final model was bootstrapped with 1000 bootstrap samples to test internal validity. All statistical analysis was performed using IBM SPSS Statistics, v.26 (IBM Corp., Armonk, NY, USA) and statistical significance was set using a two-sided *p* value <0.05.

Results

A total of 11,703 patients underwent RC and WD occurred in 324 patients (2.8%) within 30 days of surgery. The age group mostly affected by WD was patients aged 70–79 years and 90% of WD cases occurred in male patients. Smoker status was more common among WD cases (34% *versus* 23%), as was having a higher ASA classification (82% *versus* 76%). Medical history showed a significantly increased prevalence of hypertension (65%), dyspnea (15%), and COPD (15%) among patients who had WD. A full summary of demographic and preoperative factors is shown in Table 1.

There was no significant difference in diversion types between the WD and non-WD groups, and although cases with WD had a higher proportion of operative times exceeding 450 min (23% *versus* 19%), the difference was not statistically significant. No difference was seen in surgical wound closure approaches or wound classifications. To note, the presence of 'any surgical site infection' was notably increased and significant in WD cases (49% *versus* 12%). Table 2 contains the summary of operative characteristics and postoperative wound occurrences.

The exploratory univariate analysis yielded nine factors eligible for inclusion into the multivariate model: male gender [odds ratio (OR) = 2.2, 95% confidence interval (CI) = 1.5–3.1], smoking (OR = 1.8, 95% CI =1.4–2.2), ASA class >2 (OR = 1.4, 95% CI = 1.1–1.9), anemia (OR = 1.3, 95% CI =1.1–1.8), hypertension (OR = 1.3, 95% CI =1.0–1.6), dyspnea (OR = 1.9, 95% CI = 1.4–2.6), COPD (OR = 2.3, 95% CI = 1.7–3.1), any surgical site infection (SSI) (OR = 2.8, 95% CI = 2.1–3.9), and weight classes: overweight (OR = 1.5, 95% CI = 1.1–2.1), class 1 (OR = 1.8, 95% CI = 1.3–2.5), class 2 (OR = 2.4, 95% CI = 1.6–3.6), class 3 (OR = 3.7, 95% CI = 2.4–5.9). A full summary is shown in Table 4.

Multivariate logistic regression analysis yielded a final risk model comprised of five factors: sex, smoking status, history of COPD, presence of SSI, and weight class. Table 3 provides the final model factors with their adjusted ORs and 95% CIs. The model ROC analysis (Figure 1) provided a C-statistic of 0.76 (95% CI = 0.73–0.79), and calibration testing (Figure 2) provided an R^2 of 0.99. The model was bootstrapped and provided valid ORs for all six factors as shown in Table 5.

Discussion

In this study, we developed a robust risk-prediction model for WD following RC using a large multi-institutional cohort. The incidence of WD within 30 days of RC was found to be 2.8%, which was similar to that found by Meyer *et al.*[11] and Sathianathen *et al.*,[13] who reported incidence rates of 3.2% and 3.3%, respectively, whereas Novotny *et al.*[12] and Mazzone *et al.*[21] reported much higher rates of 8.9% and 6.4%, respectively. This discrepancy in the literature could be attributed to several confounding factors such as improved surgical techniques over the years since the cohorts with higher rates were earlier series.

Table 1. Summary of demographic factors, preoperative laboratory results, and medical conditions.

		No WD	Yes WD	Total	*p* value
		n (% of 11,379)	*n* (% of 324)	*N* (% of 11,703)	
Demographic factors					
Age	Below 50	730 (6.4)	18 (5.6)	748 (6.4)	0.583
	50–59	1878 (16.5)	55 (17.0)	1933 (16.5)	0.532
	60–69	3721 (32.7)	104 (32.1)	3825 (32.7)	0.628
	70–79	3850 (33.8)	120 (37.0)	3970 (33.9)	0.360
	>80	1200 (10.6)	27 (8.3)	1227 (10.5)	0.766
Gender	Male	9103 (80.0)	291 (89.8)	9394 (80.3)	
	Female	2276 (20.0)	33 (10.2)	2309 (19.7)	<0.001
Race	White	8762 (77.0)	237 (73.2)	8999 (76.9)	0.015
	Black	516 (4.5)	12 (3.7)	528 (4.5)	0.614
	Other	188 (1.7)	1 (0.3)	189 (1.6)	0.106
Hispanic ethnicity		289 (2.5)	4 (1.2)	293 (2.5)	0.204
Smoker		2603 (22.9)	111 (34.3)	2714 (23.2)	<0.001
ASA class	⩽2	2717 (23.9)	59 (18.2)	2776 (23.8)	
	>2	8641 (76.1)	265 (81.8)	8906 (76.2)	0.018
Weight	Normal	3151 (27.7)	56 (17.3)	3207 (27.4)	<0.001
	Overweight	4371 (38.4)	120 (37.0)	4491 (38.4)	0.008
	Class 1	2514 (22.1)	80 (24.7)	2594 (22.2)	<0.001
	Class 2	877 (7.7)	37 (11.4)	914 (7.8)	<0.001
	Class 3	466 (4.1)	31 (9.6)	497 (4.3)	<0.001
Laboratory results					
Anemia		4125 (36.3)	95 (29.3)	4220 (36.1)	0.011
Abnormal creatinine		3559 (31.3)	104 (32.1)	3663 (31.3)	0.753
Hypoalbuminemia		1216 (16.6)	37 (17.5)	1253 (16.6)	0.736
Leukocytosis		1729 (15.2)	59 (18.2)	1788 (15.3)	0.138
Thrombocytopenia		1127 (9.9)	35 (10.8)	1162 (9.9)	0.594
Medical conditions					
Hypertension		6747 (59.3)	212 (65.4)	6959 (59.5)	0.027
Diabetes		2237 (19.7)	60 (18.5)	2297 (19.6)	0.610
Dyspnea		963 (8.5)	49 (15.1)	1012 (8.7)	<0.001

(Continued)

Table 1. (Continued)

	No WD	Yes WD	Total	*p* value
	n (% of 11,379)	*n* (% of 324)	*N* (% of 11,703)	
COPD	841 (7.4)	50 (15.4)	891 (7.6)	<0.001
Disseminated cancer	682 (6.0)	17 (5.3)	699 (6.0)	0.576
Steroid use	402 (3.5)	16 (4.9)	418 (3.6)	0.181
Bleeding disorders	382 (3.4)	14 (4.3)	396 (3.4)	0.345
Unintentional WL	329 (2.9)	8 (2.5)	337 (2.9)	0.654
pRBC transfusion	201 (1.8)	7 (2.2)	208 (1.8)	0.597
Sepsis	181 (1.6)	5 (1.5)	186 (1.6)	0.946
CHF	81 (0.7)	4 (1.2)	85 (0.7)	0.281
Dialysis	69 (0.6)	1 (0.3)	70 (0.6)	0.501
Acute renal failure	46 (0.4)	0 (0.0)	46 (0.4)	0.998
Ascites	9 (0.1)	0 (0.0)	9 (0.1)	0.998

ASA, American Society of Anesthesiologists; BMI, body mass index; CHF, congestive heart failure; COPD, chronic obstructive pulmonary disease; pRBC transfusion, receiving packed red blood cells within 72 h of operation; unintentional WL, >10% unintentional weight loss within 6 months of operation; WBC, white blood cell count; WD, wound dehiscence. Weight classes BMI ranges (kg/m^2): normal (<25.0), overweight (25.0–29.9), class 1 (30.0–34.9), class 2 (35.0–39.9), class 3 (⩾40.0); anemia indicates hematocrit <36%; abnormal creatinine is serum creatinine >1.2 mg/dl; hypoalbuminemia is serum albumin <3.4 g/dl; leukocytosis is WBC >10^3; thrombocytopenia is platelet count <150 × 10^3; Hypertension indicates diagnosed hypertension on medical treatment.

Table 2. Summary of operative characteristics, wound characteristics, and postoperative wound occurrences.

		No dehiscence	Yes dehiscence	Total	*p* value
		n (%)	*n* (%)	*N* (%)	
Operative characteristics					
Diversion type	IC or SB + LND	7059 (62.0)	191 (59.0)	7250 (62.0)	0.503
	IC or SB	2045 (18.0)	63 (19.4)	2108 (18.0)	0.880
	Neobladder	1936 (17.0)	58 (17.9)	1994 (17.0)	0.813
	USD or UCD + LND	119 (1.1)	4 (1.2)	123 (1.1)	0.827
Operative time	<250	2688 (23.6)	85 (26.2)	2773 (23.7)	0.017
	250–349	3763 (33.1)	81 (25.0)	3844 (32.9)	0.014
	350–449	2810 (24.7)	84 (25.9)	2894 (24.7)	0.719
	450+	2118 (18.6)	74 (22.8)	2192 (18.7)	0.537
pRBC transfusion		146 (47.4)	2 (22.2)	148 (46.7)	0.156

(Continued)

Table 2. (Continued)

		No dehiscence	Yes dehiscence	Total	*p* value
		n (%)	*n* (%)	*N* (%)	
Wound closure	All layers closed	7894 (99.7)	215 (99.5)	8109 (99.7)	0.649
	No layers closed	12 (0.2)	0 (0.0)	12 (0.2)	0.999
	Only deep layers closed	14 (0.2)	1 (0.5)	15 (0.2)	0.353
Wound classification	Clean	189 (1.7)	8 (2.5)	197 (1.7)	0.381
	Clean/contaminated	10474 (92.1)	290 (89.5)	10764 (92.0)	0.246
	Contaminated	598 (5.3)	21 (6.5)	619 (5.3)	0.659
	Dirty/infected	118 (1.0)	5 (1.5)	123 (1.1)	0.999
Postoperative wound occurrences					
Wound dehiscence		–	324 (100)	324 (2.8)	–
Any SSI		1405 (12.4)	157 (48.5)	1562 (13.4)	<0.001
Superficial SSI		642 (5.6)	47 (14.5)	689 (5.9)	<0.001
Deep incisional SSI		128 (1.1)	51 (15.7)	179 (1.5)	<0.001
Organ space SSI		705 (6.2)	69 (21.3)	774 (6.6)	<0.001

IC, ileal conduit; LND, lymph node dissection; pRBC, indicates packed red blood cells; SB, sigmoid bladder; SSI, surgical site infection; UCD, ureterocutaneous diversion; USD, ureterosigmoid diversion.
Operative time is in minutes.

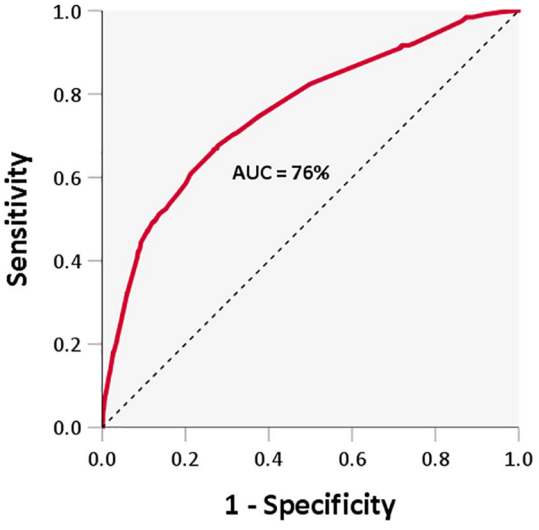

Figure 1. The receiver operated curve (ROC) for the final multivariate logistic regression model showing the area under the curve (AUC) or C-statistic *versus* the reference line.

Our risk-prediction model accounts for five clinically relevant risk factors contributing to the incidence of WD: sex, smoking, history of COPD, incidence of SSI, and weight class. Male gender more than doubles the risk of WD and this finding is concordant with the literature in which female gender was found to be protective.[11] On the contrary, wound infection is a widely described risk factor for WD and was the strongest predictor in our study as it demonstrated a sixfold increase in the odds of WD. Wound infection increases inflammation at the incision site, resulting in an alteration of the architecture of the wound and thus disrupting the normal healing process.[22] Meyer *et al.*[11] found that wound infection increases the risk of WD by 4.8 folds in RC. In another study, SSI was found to have a threefold increase in incidence of WD and conferred a 3.7-fold increase in incisional hernia after midline laparotomy.[23] In addition to wound infection, smoking is a proven risk factor for delayed wound

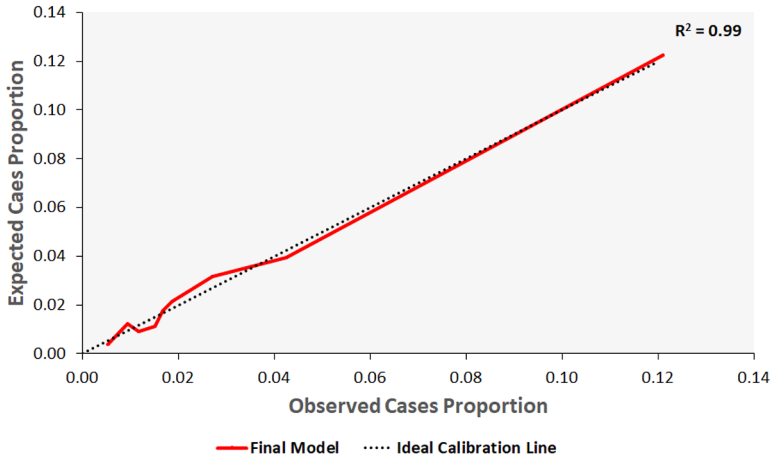

Figure 2. The overall calibration for the final multivariate logistic regression model using the Hosmer–Lemeshow test contingency table, showing the coefficient of determination (R^2) of observed *versus* expected proportion of wound dehiscence cases.

Table 3. Multivariable logistic regression model for wound dehiscence within 30 days of radical cystectomy.

Factor	Estimate	Standard error	Adjusted OR	95% CI
Gender (male)	0.92	0.19	2.52	1.74–3.65
Smoker	0.60	0.13	1.81	1.42–2.32
History of COPD	0.65	0.17	1.91	1.38–2.64
Any SSI	1.84	0.12	6.32	5.02–7.95
Overweight	0.42	0.17	1.52	1.09–2.11
Obesity class 1	0.53	0.18	1.69	1.18–2.41
Obesity class 2	0.68	0.22	1.97	1.27–3.04
Obesity class 3	1.07	0.24	2.90	1.81–4.65

CI, confidence interval; COPD, chronic obstructive pulmonary disease; OR, odds ratio; SSI, surgical site infection.

healing (OR = 1.8, $p < 0.001$), a finding which is supported by a propensity-matched cohort analysis that determined that smoking increases the odds of WD by 1.9 fold ($p = 0.028$). Smoking contributes to delayed wound healing by compromising the blood supply, by inducing vasoconstriction; tobacco smoking also hampers wound healing by hindering tissue repair and the inflammatory responses due to the toxic compounds found in cigarette smoke, mainly carbon monoxide and hydrogen cyanide.[24,25]

Our analysis also found that a history of COPD (OR = 1.9, $p < 0.001$) doubles the odds of WD incidence, confirming the findings in the literature reporting twofold and threefold increases in dehiscence among COPD patients.[11,16] Pulmonary health is imperative in the wound healing process, as adequate oxygenation is required for the development of durable tissue and minimizing the incidence of wound complications. COPD is also generally a consequence of tobacco smoking that in itself has been proven to disrupt normal wound healing.[26] In addition, COPD patients suffer from chronic cough that would increase intrabdominal pressure and lead to wound disruption and delayed healing.[10] Finally, obesity and increasing BMI are well-documented risk factors for WD in

major abdominal surgeries. Our model provides a weight class stratification, with risk of WD increasing exponentially with increasing BMI. Even overweight patients (OR = 1.5, $p = 0.013$) with a BMI between 25 and 30 kg/m^2 saw an increase in odds of WD and morbidly obese patients with a BMI of 40 kg/m^2 or higher saw a threefold (OR = 2.9, $p < 0.001$) increase in WD odds. Several studies have shown that increasing BMI is linked to increased risks of WD and other wound complications.[11,27] Reduced vascularity of adipose tissues, suppressed lymphatic immunity, and reduced subcutaneous tissue oxygenation are among several factors that were reported to contribute to wound infection and dehiscence among obese patients.[28]

Other risk factors such as age, race, ascites, hematocrit, and creatinine were not significantly associated with WD after adjusting for the aforementioned factors. Age has been explored as a potential risk factor for postoperative complications by Mazzone *et al.*,[21] and similar to our findings, its relationship with WD was found to be nonsignificant. Moreover, Novotny *et al.*[29] showed that the risk of WD in patients younger or older than 70 years old were similar, 4.5% and 4.9%, respectively, confirming our finding that age is not a significant predictor of WD.

Limitations

This study has several limitations. In the ACS-NSQIP data set, the CPT codes included to indicate RC do not indicate the approach (open, robotic, or laparoscopic). Hence, a comparison or exclusion of robotic cases was not possible and such a comparison could have been important to explore. Our model could have missed important risk factors that are not included in the ACS-NSQIP database. For example, the presence of preoperative cough, malnutrition, and postoperative hemorrhage requiring blood transfusions are all factors that were shown to increase the risk of WD in abdominal surgeries in the literature[10,14–16] but were not included in our analysis due to lack of data in the ACS-NSQIP database. Moreover, there is no information about the type of abdominal closure and the type of threads and needles used, all of which have been shown to be predictive of wound-related complications.[30]

Conclusion

WD is a postoperative complication that carries significant morbidity in RC patients. The authors propose a five-factor risk-prediction model comprised of sex, smoking status, history of COPD, SSI, and weight classification. Predicting the risk of WD incidence following RC would allow for the improvement of preoperative counseling through addressing modifiable risk factors and the optimization of perioperative care for patients at high risk.

Author contributions

AAN contributed to conceptualization, methodology, software, writing – original draft preparation. MM contributed to conceptualization and writing – original draft preparation. NFAH contributed to methodology, visualization, and investigation. CA and JAN contributed to investigation and writing – original draft preparation. HT contributed to methodology and resources. AEH contributed to writing – reviewing and editing and supervision.

Conflict of interest

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Data availability

The data are subject to a data use agreement and can be accessed by request from the ACS-NSQIP participant use form (https://www.facs.org/quality-programs/acs-nsqip/participant-use).

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Appendix 1

Table 4. The univariate logistic regression analysis results for all clinical variables with the outcome of WD incidence within 30 days of operation.

		No WD	Yes WD	Total	OR (95% CI)	*p* value
		n **(% of 11,379)**	***n*** **(% of 324)**	***N*** **(% of 11,703)**		
Demographics						
Age	<50	730 (6.4)	18 (5.6)	748 (6.4)		0.583
	50–59	1878 (16.5)	55 (17)	1933 (16.5)	1.19 (0.69–2.04)	0.532
	60–69	3721 (32.7)	104 (32.1)	3825 (32.7)	1.13 (0.68–1.88)	0.628
	70–79	3850 (33.8)	120 (37)	3970 (33.9)	1.26 (0.77–2.09)	0.360
	>80	1200 (10.6)	27 (8.3)	1227 (10.5)	0.91 (0.5–1.67)	0.766
Gender	Female	2276 (20)	33 (10.2)	2309 (19.7)		
	Male	9103 (80)	291 (89.8)	9394 (80.3)	2.21 (1.53–3.17)	<0.001
Race	White	8762 (77)	237 (73.2)	8999 (76.9)	0 (0–0)	0.015
	Black	516 (4.5)	12 (3.7)	528 (4.5)	0.86 (0.48–1.55)	0.614
	Other	188 (1.7)	1 (0.3)	189 (1.6)	0.2 (0.03–1.41)	0.106
	Unknown	1913 (16.8)	74 (22.8)	1987 (17)	1.43 (1.1–1.87)	0.008
Hispanic		289 (2.5)	4 (1.2)	293 (2.5)	0.53 (0.19–1.42)	0.204
Smoker		2603 (22.9)	111 (34.3)	2714 (23.2)	1.76 (1.39–2.22)	<0.001
ASA class	⩽2	2717 (23.9)	59 (18.2)	2776 (23.8)		
	>2	8641 (76.1)	265 (81.8)	8906 (76.2)	1.41 (1.06–1.88)	0.018
Weight class	Normal	3151 (27.7)	56 (17.3)	3207 (27.4)		<0.001
	Overweight	4371 (38.4)	120 (37)	4491 (38.4)	1.55 (1.12–2.13)	0.008
	Class 1	2514 (22.1)	80 (24.7)	2594 (22.2)	1.79 (1.27–2.53)	0.001
	Class 2	877 (7.7)	37 (11.4)	914 (7.8)	2.37 (1.56–3.62)	<0.001
	Class 3	466 (4.1)	31 (9.6)	497 (4.3)	3.74 (2.39–5.87)	<0.001
Lab results						
Anemia		4125 (36.3)	95 (29.3)	4220 (36.1)	1.37 (1.08–1.75)	0.011

(Continued)

Table 4. (Continued)

		No WD	Yes WD	Total	OR (95% CI)	*p* value
		n (% of 11,379)	*n* (% of 324)	*N* (% of 11,703)		
Abnormal creatinine		3559 (31.3)	104 (32.1)	3663 (31.3)	1.04 (0.82–1.32)	0.753
Hypoalbuminemia		1216 (16.6)	37 (17.5)	1253 (16.6)	1.06 (0.74–1.53)	0.736
Leukocytosis		1729 (15.2)	59 (18.2)	1788 (15.3)	1.24 (0.93–1.66)	0.138
Thrombocytopenia		1127 (9.9)	35 (10.8)	1162 (9.9)	1.1 (0.77–1.57)	0.594
Medical conditions						
Hypertension		6747 (59.3)	212 (65.4)	6959 (59.5)	1.3 (1.03–1.64)	0.027
Diabetes		2237 (19.7)	60 (18.5)	2297 (19.6)	0.93 (0.7–1.23)	0.610
Dyspnea		963 (8.5)	49 (15.1)	1012 (8.7)	1.93 (1.41–2.63)	<0.001
COPD		841 (7.4)	50 (15.4)	891 (7.6)	2.29 (1.68–3.12)	<0.001
Disseminated cancer		682 (6)	17 (5.3)	699 (6)	0.87 (0.53–1.42)	0.576
Steroid use		402 (3.5)	16 (4.9)	418 (3.6)	1.42 (0.85–2.37)	0.181
Bleeding disorders		382 (3.4)	14 (4.3)	396 (3.4)	1.3 (0.75–2.24)	0.345
Unintentional WL		329 (2.9)	8 (2.5)	337 (2.9)	0.85 (0.42–1.73)	0.654
pRBC transfusion		201 (1.8)	7 (2.2)	208 (1.8)	1.23 (0.57, 2.63)	0.597
Sepsis		181 (1.6)	5 (1.5)	186 (1.6)	0.97 (0.4–2.37)	0.946
CHF		81 (0.7)	4 (1.2)	85 (0.7)	1.74 (0.64–4.79)	0.281
Dialysis		69 (0.6)	1 (0.3)	70 (0.6)	0.51 (0.07–3.67)	0.501
Acute renal failure		46 (0.4)	0 (0)	46 (0.4)	0 (0–0)	0.998
Ascites		9 (0.1)	0 (0)	9 (0.1)	0 (0–0)	0.998
Operative characteristics						
Diversion type	IC or SB + LND	7059 (62)	191 (59)	7250 (62)	0.9 (0.67–1.22)	0.503
	IC or SB	2045 (18)	63 (19.4)	2108 (18)	1.03 (0.72–1.48)	0.880
	Neobladder	1936 (17)	58 (17.9)	1994 (17)	0 (0–0)	0.813
	USD or UCD + LND	119 (1.1)	4 (1.2)	123 (1.1)	1.12 (0.4–3.14)	0.827
Operative time	Below 250	2688 (23.6)	85 (26.2)	2773 (23.7)		0.017
	250–349	3763 (33.1)	81 (25)	3844 (32.9)	0.68 (0.5–0.93)	0.014
	350–449	2810 (24.7)	84 (25.9)	2894 (24.7)	0.95 (0.7–1.28)	0.719
	450+	2118 (18.6)	74 (22.8)	2192 (18.7)	1.11 (0.81–1.52)	0.537
pRBC transfusion	Yes	146 (47.4)	2 (22.2)	148 (46.7)	0.32 (0.07–1.55)	0.156

(Continued)

Table 4. (Continued)

		No WD	Yes WD	Total	OR (95% CI)	*p* value
		n (% of 11,379)	*n* (% of 324)	*N* (% of 11,703)		
Surgical wound closure	All layers	7894 (99.7)	215 (99.5)	8109 (99.7)		0.649
	No layers	12 (0.2)	0 (0)	12 (0.2)	0 (0–0)	0.999
	Only deep layers	14 (0.2)	1 (0.5)	15 (0.2)	2.62 (0.34–20.03)	0.353
Wound classification	Clean or none	189 (1.7)	8 (2.5)	197 (1.7)	0 (0–0)	0.381
	Clean/contaminated	10474 (92.1)	290 (89.5)	10764 (92)	0.65 (0.32–1.34)	0.246
	Contaminated	598 (5.3)	21 (6.5)	619 (5.3)	0.83 (0.36–1.9)	0.659
	Dirty/infected	118 (1)	5 (1.5)	123 (1.1)	1 (0.32–3.13)	0.999
Postoperative occurrences						
WD		0 (0)	324 (100)	324 (2.8)	NA	
Any SSI		1405 (12.4)	157 (48.5)	1562 (13.4)	6.67 (5.33–8.36)	<0.001
Superficial SSI		642 (5.6)	47 (14.5)	689 (5.9)	2.84 (2.06–3.91)	<0.001
Deep incisional SSI		128 (1.1)	51 (15.7)	179 (1.5)	16.42 (11.62–23.21)	<0.001
Organ space SSI		705 (6.2)	69 (21.3)	774 (6.6)	4.1 (3.11–5.4)	<0.001

ASA, American Society of Anesthesiologists; BMI, body mass index; CHF, congestive heart failure; CI, confidence interval; COPD, chronic obstructive pulmonary disease; IC, ileal conduit; LND, lymph node dissection; OR, odds ratio; pRBC, packed red blood cells; pRBC transfusion, receiving packed red blood cells within 72 h of operation; SB, sigmoid bladder; SSI, surgical site infection; UCD, ureterocutaneous diversion; unintentional WL, >10% unintentional weight loss within 6 months of operation; USD, ureterosigmoid diversion; WBC, white blood cell count; WD, wound dehiscence.
Obesity classes BMI ranges (kg/m^2): normal (<25.0), overweight (25.0–29.9), class 1 (30.0–34.9), class 2 (35.0–39.9), class 3 (⩾40.0); anemia indicates hematocrit <36%; abnormal creatinine is serum creatinine >1.2 mg/dl; hypoalbuminemia is serum albumin <3.4 g/dl; leukocytosis is WBC >103; thrombocytopenia is platelet count <150 × 103; hypertension indicates diagnosed hypertension on medical treatment; operative time is in minutes.

Table 5. 1000 bootstrap sample with 95% confidence intervals for the final five-factor model.

Factor	β	Bias	Error	*p* value	95% confidence interval	
					Lower	Upper
Gender (Male)	0.923	0.017	0.192	0.001	0.585	1.338
Smoker	0.595	−0.001	0.123	0.001	0.351	0.835
History of COPD	0.646	−0.009	0.17	0.002	0.296	0.963
Any SSI	1.844	0.001	0.117	0.001	1.612	2.075
Overweight	0.418	0.005	0.17	0.014	0.106	0.774
Obesity class 1	0.525	0.006	0.19	0.003	0.169	0.905
Obesity class 2	0.676	−0.011	0.228	0.004	0.203	1.094
Obesity class 3	1.066	−0.007	0.249	0.001	0.574	1.561
Constant	−5.519	−0.027	0.23	0.001	−6.022	−5.118

BMI, body mass index; COPD, chronic obstructive pulmonary disease; SSI, surgical site infection.
Weight classes BMI ranges (kg/m^2): overweight (25.0–29.9), class 1 (30.0–34.9), class 2 (35.0–39.9), and class 3 (⩾40.0).