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Urinary tract infection after surgery for colorectal malignancy: risk factors and complications

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Abstract

BACKGROUND—Over 4% of patients undergoing colorectal surgery develop postoperative urinary tract infection (UTI).

METHODS—Using 2005 to 2012 American College of Surgeons National Surgical Quality Improvement Program data for 47,781 patients, we examined independent risk factors and complications associated with UTI using multivariate logistic regression.

RESULTS—Independent predictors of UTI included female sex (odds ratio [OR] 1.705, 95% confidence interval [CI] 1.508 to 1.928), open procedure (OR 1.419, 95% CI 1.240 to 1.624), rectal procedure (OR 1.267, 95% CI 1.105 to 1.453), age greater than 65 years (OR 1.322, 95% CI 1.151 to 1.519), nonindependent functional status (OR 1.609, 95% CI 1.299 to 1.993), steroid use (OR 1.524, 95% CI 1.116 to 2.080), higher anesthesia class, and longer operative time. Patients with UTI had longer hospital stays (7 vs 12 days), higher reoperation rates (11.9% vs 5.1%), and higher 30-day mortality (3.3% vs 1.7%). Postoperative UTI correlated with other complications, including sepsis, surgical site infections, and pulmonary embolism ($P < .001$).

CONCLUSIONS—Postoperative UTI in colorectal surgery patients correlates with increased morbidity and mortality. Patients who contract postoperative UTI may be more likely to develop multiple complications.

Keywords

Colorectal surgery; Urinary tract infection; Surgical outcomes; Colorectal malignancy

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Despite aggressive prevention programs and best practice recommendations, urinary tract infection (UTI) remains a prevalent hospital-acquired infection, particularly in patients with an indwelling urinary catheter.[1–3] UTI has been shown to prolong hospital stay, increase cost of care, and increase mortality.[4–6] In 2008, the Centers for Medicare and Medicaid Services began a policy of nonpayment for hospital-acquired UTI and several other "reasonably preventable events."[7] This policy, however, fails to account for differences in the risk of UTI because of intrinsic patient and procedure factors.

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In surgical patients, a disparity in UTI incidence has been identified between different types of procedures, with rates of UTI significantly higher after colorectal resection than other surgeries. One study found crude UTI rate after colorectal resection (4.1%) to be more than twice that as after other gastrointestinal procedures (1.8%) and more than 3 times higher than after nongastrointestinal procedures (1.2%).[8] Colorectal procedure is an independent risk factor for postsurgical UTI.[9] While colorectal surgery sees a disproportionate share of surgical morbidity because of UTI, few studies have examined the relationship between UTI and other postoperative complications.

In the setting of increasing scrutiny on postsurgical outcomes, nonpayment for the so-called “preventable” complications, and significant increased risk of UTI in patients undergoing colorectal surgery, we sought to identify independent risk factors for UTI in patients undergoing resection procedures for colorectal malignancy. Additionally, we examined the relationship of UTI to other postsurgical complications, as clusters of complications may be to blame for the high excess morbidity and mortality caused by UTI. By identifying these high-risk patients and their related complications, we hope to aid the design of evidence-based interventions to prevent excess morbidity and mortality associated with postoperative UTI in this population.

Patients and Methods

Data acquisition and patient selection

The American College of Surgeons National Surgical Quality Improvement Program (NSQIP) database collects preoperative, operative, and 30-day outcome data on patients undergoing major operations at both academic and community hospitals around the United States. This database, including sampling methods, data collection, and outcomes, has been described in detail elsewhere.[10] We obtained the participant use files for the NSQIP database from 2005 to 2012. NSQIP participant use files have been considered exempt from institutional review board review at the University of Wisconsin-Madison. All 1,904,781 patients in this dataset were considered for inclusion in this study. Patients were selected using International Classification of Diseases-9 codes for colorectal malignancy (153.0 to 153.9, 154.0 to 154.1). Resection procedures were selected using Current Procedural Terminology (CPT) codes (44140, 44141, 44143, 44144, 44145, 44146, 44147, 44150, 44151, 44152, 44153, 44155, 44156, 44157, 44158, 44160, 44204, 44205, 44206, 44207, 44208, 44210, 44211, 44212, 45110, 45111, 45112, 45113, 45119, 45120, 45395, 45397). Emergency cases, American Society of Anesthesiologists (ASA) Class 5 patients, and patients with preoperative sepsis, shock, ventilator dependence, or coma were excluded.

Risk factor and outcome variables

Preoperative variables studied included sex (categorical: male, female), age (categorical: <20, 20 to 29, 30 to 39, 40 to 49, 50 to 59, 60 to 69, 70 to 79, 80 to 89, 90+ years; <65 and 65+ years), race (categorical: American Indian or Alaska Native, Asian, black or African American, Native Hawaiian or Pacific Islander, white, unknown), body mass index (calculated from given height and weight; categorical: <18.5 [underweight], 18.5 to 24.9 [normal], 25.0 to 29.9 [overweight], 30.0 to 49.9 [obese], >50.0 [super-obese]), admission quarter (categorical: 1, 2, 3, 4), and comorbidities (diabetes mellitus, current smoker, alcohol use of >2 drinks/day, dyspnea, nonindependent functional status, pneumonia, ascites, esophageal, gastric, or intestinal disease, history of congestive heart failure, history of myocardial infarction, previous percutaneous coronary intervention, previous cardiac surgery, history of angina, history of hypertension, history of peripheral vascular disease, rest pain, dialysis, impaired sensorium, hemiplegia, history of transient ischemic attack (TIA), history of cerebral vascular accident or stroke with neurological deficit, history of cerebral vascular accident or stroke without neurological deficit, tumor invading central nervous system, paraplegia, quadriplegia, disseminated cancer, open wound or wound infection, steroid use for a chronic condition, >10% loss of body weight in the past 6 months, history of bleeding disorder, transfusion of >4 U of packed red blood cells in the 72 hours before surgery, neoadjuvant chemotherapy, neoadjuvant radiotherapy, prior operation within 30 days, and meeting systemic inflammatory response syndrome (SIRS) criteria; categorical: yes, no). Operative variables included wound class (categorical: 1 [clean], 2 [clean contaminated], 3 [contaminated], 4 [dirty/infected]), anesthesia class (categorical: 1 [no disturbance], 2 [mild disturbance], 3 [severe disturbance], 4 [life-threatening disturbance]), procedure type (determined by CPT code; categorical: laparoscopic, open), anatomic location (determined by CPT code; categorical: colon, rectum), total operative time (continuous; minutes), and units of blood transfused during surgery (categorical: 0, 1, 2, >2).

The primary outcome variable of interest was UTI within 30 days of the index operation, as defined by the NSQIP.[11] Additional 30-day outcome variables studied (all categorical: yes, no) included superficial surgical site infection (SSI), deep SSI, organ/space SSI, wound disruption, pneumonia, reintubation, pulmonary embolism, greater than 48 hours on ventilator, progressive renal insufficiency, acute renal failure, stroke or cerebral vascular accident, coma, peripheral nerve injury, cardiac arrest, myocardial infarction, hemorrhage, deep vein thrombosis, sepsis, septic shock, return to the operating room, and death. The number of days from operation to discharge was also examined (continuous; days).

Statistical analysis

All statistical analysis was performed using SPSS Statistics 22 (IBM; Armonk, NY). Preoperative and operative variables were compared between patients with and without postoperative UTI, using chi-square analysis for categorical variables and the Mann–Whitney *U* test for continuous variables. All preoperative and operative variables found to have a *P* value less than .1 in this univariate analysis were included in a logistic regression model to identify independent predictors of postoperative UTI. Pearson's correlation between variables was examined to avoid multicollinearity. Independent predictors were described using estimated odds ratios (ORs) and 95% confidence intervals (CI). Outcome variables other than UTI were examined using individual logistic regression models including previously identified preoperative and operative variables found to have a *P* value less than .1 in univariate analysis as well as the outcome variable of interest, with UTI as the dependent variable. The fold increase in complication rates was determined by dividing the percentage of patients with UTI experiencing the complication by the percentage of patients without UTI experiencing the complication.

Results

Crude urinary tract infection rate in patients undergoing resection for colorectal malignancy

A total of 47,781 patients were identified and included in our analysis. Overall, 3.7% (n = 1,764) of the patients developed postoperative UTI.

Univariate analysis of preoperative and operative risk factors for urinary tract infection

Univariate analysis of demographics, preoperative comorbidities, and operative variables is shown in Tables 1–3. Female patients had a higher rate of UTI (4.5% vs 3.0% in men). UTI rates sharply increased with age; while the overall rate of UTI was 3.7%, the rates in those aged 70 to 79, 80 to 89, and 90+ years were 3.9%, 5.1%, and 5.9%, respectively. Those undergoing laparoscopic procedures had a significantly lower rate of UTI (2.7%) than those undergoing an open procedure (4.4%). UTI was more common after procedures involving the rectum (4.5%) than those involving the colon alone (3.2%). Superobese patients developed UTI at a rate of 6.5%, compared with 3.7% of those with a normal BMI. Unsurprisingly, several comorbid conditions were also correlated with higher rates of UTI.

Independent preoperative and operative predictors of postoperative urinary tract infection

When a logistic regression model was applied including all preoperative and operative variables with a P value less than .1 in univariate analysis, several variables remained independent predictors of postoperative UTI; these variables are listed in Table 4. Female patients had a significantly increased risk of UTI compared with male patients (OR 1.705, 95% CI 1.508 to 1.928). Patients over the age of 65 had an increased risk compared with younger patients (OR 1.322, 95% CI 1.151 to 1.519). The preoperative comorbidities which remained predictive of postoperative UTI were nonindependent functional status (OR 1.609, 95% CI 1.299 to 1.993), history of TIA (OR 1.394, 95% CI 1.053 to 1.846), steroid use for a chronic condition (OR 1.524, 95% CI 1.116 to 2.080), meeting SIRS criteria (OR 1.393, 95% CI 1.016 to 1.911), and transfusion of greater than 4 U of packed red blood cells within 72 hours of surgery (OR 1.494, 95% CI 1.004 to 2.221). ASA Class 4 was shown to significantly increase UTI risk (OR 2.146, 95% CI 1.194 to 3.856). Open procedures (OR 1.419, 95% CI 1.240 to 1.624) and procedures involving the rectum (OR 1.267, 95% CI 1.105 to 1.453) were both independent predictors of UTI. Longer total operation time was also found to increase postoperative UTI risk on a per-minute basis (OR 1.002, 95% CI 1.002 to 1.003). Despite their correlation in univariate analysis, diabetes, obesity, radiotherapy, wound class, and several other variables lost their predictive value in multivariate analysis.

Postoperative urinary tract infection is associated with increased morbidity and mortality

Patients who suffered postoperative UTI had an average hospital stay 5 days longer than those who did not contract a UTI (7.2 vs 12.2 days, $P < .001$). They also had significantly higher reoperation rates (11.9% vs 5.1%, $P < .001$). Of patients with postoperative UTI, 3.3% had death with 30 days of surgery, compared with 1.7% of those without UTI after surgery ($P < .001$).

After controlling for preoperative and operative variability, UTI was correlated with several other postoperative complications. Of patients with UTI (n = 1,764), 56.5% (n = 997) had one or more additional complications. Patients with UTI developed sepsis or met SIRS criteria at a rate of 20.7%, compared with 3.3% in patients who did not have UTI postoperatively ($P < .001$). They similarly developed septic shock at much higher rates (6.9% vs 1.5%, $P < .001$). UTI was correlated with higher rates of SSIs, deep vein thrombosis, pulmonary embolism, renal problems, and cardiopulmonary problems, as indicated in Table 5.

Comments

As surgical outcomes are increasingly tied to reimbursement and a greater number of quality measures are publicly reported, colorectal surgeons share a disproportionate level of morbidity and cost in general surgery.[9] Multivariate models have shown that colorectal surgery is an independent risk factor for complications.[8] Despite this disadvantage, nonpayment policies and outlier designations for complications are not adjusted for case mix. For this reason and for the well-being of this high-risk population, interventions specific to colorectal surgery are needed to reduce excess morbidity, mortality, and resource use in these patients.

Studies have shown that UTI is more common after colorectal resection than other operations. A 2012 study by Kang et al[12] used similar methods to examine the Nation-wide Inpatient Sample database for risk factors of postoperative UTI and urinary retention in a population of patients undergoing resection for colorectal cancer. While their analysis similarly found female sex, older age, open procedure, and several complication events correlated with UTI, a number of preoperative variables did not compare between the 2 analyses. Kang et al conclude that proctectomy and pelvic dissection procedures conferred a higher risk of UTI in their discussion (as we found in our study), although their results appear to show the opposite trend, with colectomy procedures having an increased odds ratio for UTI compared with sigmoidectomy. Much of the discordance is likely because of differences in the standard data collection practices of the Nationwide Inpatient Sample, an administrative database, and the NSQIP, which is primarily a research database. There were also some differences in the statistical analysis used; for example, Kang et al examined postoperative variables together, while we examined them individually because of high collinearity. However, this does not explain the significant differences in rates of UTI, length of stay, and mortality. Kang et al found a much higher rate of UTI (5.91% vs 3.7%), longer length of stay for patients with UTI (17 vs 12.2 days), and significantly higher mortality rate in the UTI group (6.09% vs 3.3%). One possible explanation is that our group excluded emergency cases and those patients with preoperative sepsis, shock, ventilator dependence, and ASA Class 5, as our goal was to examine those colorectal surgery patients who could reasonably be intervened upon in the hospital setting.

Our study identified several independent predictors of UTI after surgery for colorectal malignancy. Female sex and older age are well-known risk factors for UTI in all patients.[1] Limited independence and history of TIA, both of which may limit a patient's ability for self-care, are unsurprising predictors of UTI. Immunosuppression with steroids and meeting

SIRS criteria are also logical predictors of postoperative infection. While these preoperative factors are difficult to modify for the purposes of intervention, they nevertheless identify a patient population who are at significantly increased risk for UTI, requiring a lower index of suspicion for infection and perhaps more aggressive attempts at early catheter removal, as the duration of urinary catheter placement is still one of the strongest risk factors for UTI.[4]

Numerous studies have shown that early removal of urinary catheters reduces UTI rates significantly while only slightly increasing the risk of urinary retention.[13] Strategies to reduce postoperative UTI specifically in colorectal surgery patients have had success with this strategy. Nagle et al[14] found that a daily electronic prompt requiring justification for catheters and sterile intraoperative placement of urinary catheters reduced UTI rates from 6.9% to .8% in their colorectal surgery population. Enhanced recovery after surgery protocols often include catheter removal on postoperative day 1. Miller et al[15] noted a significantly reduced postoperative UTI rate in the enhanced recovery after surgery vs conventional patient groups (13% vs 24%), although the prevalence of UTI in their patient population is quite high in both groups.

We found that the procedure involving the rectum is an independent risk factor for UTI. Pelvic dissection involves the potential for nerve injury and local inflammation that are thought to increase urinary retention after catheter removal, which could limit early removal of catheters.[16] Current recommendations are to remove urinary catheters on postoperative day 1 after nonpelvic resection and postoperative day 3 to 6 after mid to low rectal resections.[13] The exact timing of catheter removal is not clearly indicated by the current literature, although multiple clinical trials and fast-track recovery protocols are investigating this issue.

The benefits of laparoscopic colorectal surgery have been described in detail in several other studies.[17–20] Our analysis shows a significant advantage to the laparoscopic approach in preventing postoperative UTI. This may be because of the decrease in tissue trauma and pain associated with laparoscopy, leading to earlier ambulation and earlier catheter removal. Laparoscopic procedures typically involve a longer total operative time, which our analysis has shown to increase the risk of UTI after surgery. However, we found the benefit of laparoscopy to be of such magnitude that a laparoscopic procedure must run 117 minutes longer to confer the same risk of UTI as an open procedure.

In hospitalized patients, an open procedure, a more extensive pelvic dissection, or patient factors such as functional status could prevent ambulation and similarly prevent catheter removal. In our analysis, it is likely that the correlation between these factors and UTI is at least partially because of increased days of catheterization, rather than an independent increase in risk. While there are cases where continuation or reinsertion of a urinary catheter is appropriate, a catheter should not substitute for nursing care in an incontinent patient. Similarly, early catheter removal and straight catheterization in the case of urinary retention have been shown to reduce the risk of UTI.[13]

Our study also indicates that postoperative UTI is correlated with other complications, even when controlling for patient and procedural factors. For example, while only 3.3% of the patients without UTI developed sepsis, a full 20.7% of patients with UTI were considered septic or met SIRS criteria within the observation window. A higher rate of septic shock was also seen in UTI patients. Reported rates of bacteremia following bacteriuria range from 2.6% to 4.0%.[21] These studies did not examine symptomatic UTI as a separate category, although it is reasonable to assume that patients with symptomatic infections are more likely to develop systemic manifestations of the disease process. These dramatic rates of sepsis and septic shock may also be because of increased detection of UTI in patients with systemic symptoms, as urinalysis is often performed on asymptomatic patients to identify the source of a fever, for example.

UTI also correlated with higher rates of embolization events, SSIs, renal problems, and cardiopulmonary issues, even after controlling for patient and procedure factors. While the cost and difficulty in treating UTI is relatively low, these associated complications have significant effects on the length, cost, morbidity, and mortality associated with a hospital stay. High multicollinearity between postoperative complication variables prevented us from controlling for multiple outcome variables in the same model. However, this in itself indicates that patients with a UTI may be more likely to develop multiple complications.

Our statistical analysis controlled for preoperative risk factors and still demonstrated a correlation between complication events; however, it is difficult to determine the extent to which the negative outcomes experienced by patients were because of UTI vs other complication events. One way to further examine the impact of UTI on other postoperative complications and patient outcomes would be to study the temporal relationship of these events in the hospital. Unfortunately, our dataset did not include enough complication events to perform a robust statistical analysis of the chronology of adverse outcomes as they related to UTI. A larger analysis of multiple complications after colorectal surgery is indicated; determining if complications like UTI lead to additional problems could help care teams better recognize and prevent these adverse events.

Although NSQIP is a validated, audited dataset, our study was bound by the limitations of these data. For example, the NSQIP does not collect information on catheterization or time to catheter removal, which is a major modifiable risk factor for UTI. Information on the surgical procedure is limited to CPT coding, which is not robust enough to allow for further analysis of the exact level of resection. Furthermore, the national-level datasets do not include identifiers that would allow for adjustment based on provider or hospital performance. The opportunity to adjust for the institution is particularly important in the NSQIP dataset, as NSQIP participation is more common for large or academic medical centers as opposed to small community hospitals. Inability to adjust for institution also prevents examination of patients by care pathway; procedures are not standardized among NSQIP participant hospitals, so it is difficult to say, for example, why a urinalysis was performed, or what catheter management programs are in place.

Despite these limitations, our study identified a number of factors that independently confer risk for UTI after surgery for colorectal malignancy. Determining which patients are at high risk allows for aggressive attempts at early catheter removal and further study of these patients in clinical trials. We also found that postoperative UTI was associated with several other complication events, indicating that patients with UTI may be likely to experience multiple complications. Further study of the timing of these multiple complication events is needed to determine how to best intervene and prevent adverse outcomes in colorectal surgery patients.

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Table 1

Demographic variables that correlate with postoperative urinary tract infection

Characteristic	No postoperative UTI	Postoperative UTI	*P* value
All patients	46,017 (96.3)	1,764 (3.7)	
Demographics			
Sex			<.001
Male	23,887 (97.0)	729 (3.0)	
Female	22,037 (95.5)	1,031 (4.5)	
Age (years)			<.001
<20	8 (88.9)	1 (11.1)	
20–29	262 (96.0)	11 (4.0)	
30–39	1,043 (96.8)	35 (3.2)	
40–49	4,088 (97.0)	125 (3.0)	
50–59	9,382 (97.1)	281 (2.9)	
60–69	11,375 (96.8)	378 (3.2)	
70–79	11,013 (96.1)	448 (3.9)	
80–89	7,704 (94.9)	414 (5.1)	
90+	1,142 (94.1)	71 (5.9)	
Age (years)			<.001
<65	20,347 (97.0)	636 (3.0)	
65+	25,670 (95.8)	1,128 (4.2)	
Race			.015
American Indian or Alaska Native	309 (96.0)	13 (4.0)	
Asian	800 (97.3)	22 (2.7)	
Black or African American	4,494 (95.9)	193 (4.1)	
Native Hawaiian or Pacific Islander	1,036 (97.4)	28 (2.6)	
White	34,633 (96.4)	1,295 (3.6)	
Unknown	4,745 (95.7)	213 (4.3)	
BMI			.003
Underweight (<18.5)	1,301 (95.6)	60 (4.4)	
Normal (18.5–24.9)	14,424 (96.3)	555 (3.7)	
Overweight (25–29.9)	15,575 (96.6)	550 (3.4)	
Obese (30–49.9)	13,798 (96.2)	542 (3.8)	
Superobese (50+)	433 (93.5)	30 (6.5)	
Admission quarter			.008
1	11,611 (96.4)	437 (3.6)	
2	10,646 (96.5)	390 (3.5)	
3	11,886 (95.8)	518 (4.2)	
4	11,874 (96.6)	419 (3.4)	

Data are expressed as number (percentage).

BMI = body mass index; UTI = urinary tract infection.

Table 2

Preoperative comorbidities that correlate with risk for postoperative urinary tract infection

Characteristic	No postoperative UTI	Postoperative UTI	*P* value
All patients	46,017 (96.3)	1,764 (3.7)	
Preoperative comorbidities			
Diabetes mellitus			<.001
Yes	8,196 (95.6)	378 (4.4)	
No	37,821 (96.5)	1,386 (3.5)	
Dyspnea			<.001
Yes	5,425 (95.3)	268 (4.7)	
No	40,592 (96.4)	1,496 (3.6)	
Preoperative functional status			<.001
Fully independent	43,907 (96.5)	1,592 (3.5)	
Not fully independent	2,059 (92.3)	172 (7.7)	
Current pneumonia			.093
Yes	77 (92.8)	6 (7.2)	
No	33,916 (96.3)	1,314 (3.7)	
History of CHF			.009
Yes	504 (94.2)	31 (5.8)	
No	45,513 (96.3)	1,733 (3.7)	
Previous percutaneous coronary intervention			.037
Yes	2,211 (95.5)	105 (4.5)	
No	31,783 (96.3)	1,215 (3.7)	
Previous cardiac surgery			.013
Yes	2,148 (95.3)	106 (4.7)	
No	31,846 (96.3)	1,214 (3.7)	
History of hypertension			<.001
Yes	25,392 (95.9)	1,090 (4.1)	
No	20,625 (96.8)	674 (3.2)	
History of peripheral vascular disease			.041
Yes	467 (94.5)	27 (5.5)	
No	33,526 (96.3)	1,293 (3.7)	
Impaired sensorium			.043
Yes	83 (92.2)	7 (7.8)	
No	33,911 (96.3)	1,313 (3.7)	
Hemiplegia			.008
Yes	337 (93.6)	23 (6.4)	
No	33,657 (96.3)	1,297 (3.7)	
History of transient ischemic attack			<.001
Yes	976 (94.0)	62 (6.0)	
No	33,018 (96.3)	1,258 (3.7)	
History of CVA/stroke with neurological deficit			<.001

Characteristic	No postoperative UTI	Postoperative UTI	*P* value
Yes	840 (93.6)	57 (6.4)	
No	33,154 (96.3)	1,263 (3.7)	
History of CVA/stroke without neurological deficit			.081
Yes	824 (95.2)	42 (4.8)	
No	33,167 (96.3)	1,278 (3.7)	
Tumor invading CNS			.029
Yes	22 (88.0)	3 (12.0)	
No	35,289 (96.3)	1,317 (3.7)	
Paraplegia			.013
Yes	70 (90.9)	7 (9.1)	
No	33,924 (96.3)	1,313 (3.7)	
Disseminated cancer			<.001
Yes	3,497 (95.1)	181 (4.9)	
No	42,520 (96.4)	1,583 (3.6)	
Open wound or wound infection			.005
Yes	503 (94.0)	32 (6.0)	
No	45,514 (96.3)	1,732 (3.7)	
Steroid use for chronic condition			<.001
Yes	1,051 (93.9)	68 (6.1)	
No	44,966 (96.4)	1,696 (3.6)	
>10% loss of body weight in 6 months			.004
Yes	2,799 (95.3)	137 (4.7)	
No	43,218 (96.4)	1,627 (3.6)	
Bleeding disorder			.004
Yes	1,692 (95.1)	88 (4.9)	
No	44,325 (96.4)	1,676 (3.6)	
Transfusion of >4 U PRBCs in 72 h before surgery			.001
Yes	832 (94.2)	51 (5.8)	
No	45,184 (96.3)	1,713 (3.7)	
Neoadjuvant radiotherapy			<.001
Yes	3,311 (95.1)	172 (4.9)	
No	30,554 (96.4)	1,144 (3.6)	
Meets SIRS criteria			<.001
Yes	974 (94.0)	62 (6.0)	
No	44,733 (96.4)	1,690 (3.6)	
Prior operation within 30 days			.034
Yes	339 (94.2)	21 (5.8)	
No	31,473 (96.3)	1,212 (3.7)	

Data are expressed as number (percentage).

CHF = congestive heart failure; CNS = central nervous system; CVA = cardiovascular accident; PRBC = packed red blood cells; SIRS = systemic inflammatory response syndrome; UTI = urinary tract infection.

Table 3

Operative variables associated with risk for postoperative UTI

Characteristic	No postoperative UTI	Postoperative UTI	*P* value
All patients	46,017 (96.3)	1,764 (3.7)	
Operative variables			
Procedure type			<.001
Open	27,665 (95.6)	1,263 (4.4)	
Laparoscopic	18,352 (97.3)	501 (2.7)	
Anatomic location			<.001
Colon	29,397 (96.8)	981 (3.2)	
Rectum	16,620 (95.5)	783 (4.5)	
Wound class			.038
1—Clean	286 (98.3)	5 (1.7)	
2—Clean contaminated	42,240 (96.4)	1,599 (3.6)	
3—Contaminated	2,652 (95.7)	120 (4.3)	
4—Dirty/infected	839 (95.4)	40 (4.6)	
Anesthesia class			<.001
1—No disturbance	1,068 (97.9)	23 (2.1)	
2—Mild disturbance	19,477 (97.3)	546 (2.7)	
3—Severe disturbance	23,150 (95.7)	1,040 (4.3)	
4—Life threatening disturbance	2,322 (93.7)	155 (6.3)	
Total operative time (minutes)	177.1 ± 98.3	204.7 ± 117.7	<.001
Units of blood transfused			<.001
0	44,290 (96.4)	1,634 (3.6)	
1	584 (93.1)	43 (6.9)	
2	816 (94.4)	48 (5.6)	
>2	327 (89.3)	39 (10.7)	

Data are expressed as number (percentage) and mean ± standard deviation.

UTI = urinary tract infection.

Table 4

Independent risk factors for urinary tract infection

Characteristic	***P* value**	**Estimated OR (95% CI)**
Demographics		
Age >65	<.001	1.322 (1.151–1.519)
Female sex	<.001	1.705 (1.508–1.928)
Admission in 3rd quarter	.014	1.220 (1.041–1.430)
Preoperative comorbidities		
Nonindependent functional status	<.001	1.609 (1.299–1.993)
History of transient ischemic attack	.020	1.394 (1.053–1.846)
Steroid use for a chronic condition	.008	1.524 (1.116–2.080)
Meeting SIRS criteria	.039	1.393 (1.016–1.911)
Transfusion >4 U within 72 hours of surgery	.048	1.494 (1.004–2.221)
Intraoperative variables		
ASA Class 4 (vs Class 1)	.011	2.146 (1.194–3.856)
Increased total operation time*	<.001	1.002 (1.002–1.003)
Open procedure	<.001	1.419 (1.240–1.624)
Rectal procedure	.001	1.267 (1.105–1.453)

ASA = American Society of Anesthesiologists; CI = confidence interval; OR = odds ratio; SIRS = systemic inflammatory response syndrome.

*Odds ratio calculated per minute of increased operative time, actual odds ratio is 1.003-minute increased operative time.

Table 5

UTI and other postoperative complications

	n (% of group with complication)			
Variable	**No UTI**	**UTI**	**Fold increase**	**Adjusted *P* value**
Sepsis	1,509 (3.3)	365 (20.7)	6.3	<.001
Septic shock	706 (1.5)	122 (6.9)	4.6	<.001
Progressive renal insufficiency	381 (.8)	63 (3.6)	4.5	<.001
Acute renal failure	274 (.6)	41 (2.3)	3.8	<.001
Pulmonary embolism	320 (.7)	44 (2.5)	3.6	<.001
On ventilator >48 hours	797 (1.7)	101 (5.7)	3.4	<.001
Pneumonia	1,050 (2.3)	135 (7.7)	3.3	<.001
Unplanned intubation	948 (2.1)	123 (7.0)	3.3	<.001
Organ/space SSI	1,608 (3.5)	187 (10.6)	3.0	<.001
DVT	586 (1.3)	64 (3.6)	2.8	<.001
Stroke/CVA	171 (.4)	18 (1.0)	2.5	.003
Wound disruption	580 (1.3)	56 (3.2)	2.5	<.001
MI	335 (.7)	30 (1.7)	2.4	.017
Deep SSI	662 (1.4)	58 (3.3)	2.4	.034
Superficial SSI	3,402 (7.4)	266 (15.1)	2.0	<.001
Bleeding	3,332 (7.2)	246 (13.9)	1.9	.002
Total patients	46,017	1,764		

CVA = cardiovascular accident; DVT = deep vein thrombosis; MI = myocardial infarction; SSI = surgical site infection; UTI = urinary tract infection.