Ureteral Injury After Laparoscopic Versus Open Colectomy

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ABSTRACT

Background and Objectives: Ureteral injury is an infrequent but potentially lethal complication of colectomy. We aimed to determine the incidence of intraoperative ureteral injury after laparoscopic and open colectomy and to determine the independent morbidity and mortality rates associated with ureteral injury.

Methods: We analyzed data from the National Surgical Quality Improvement Program for the years 2005–2010. All patients undergoing colectomy for benign, neoplastic, or inflammatory conditions were selected. Patients undergoing laparoscopic colectomy versus open colectomy were matched on disease severity and clinical and demographic characteristics. Multivariate logistic regression analyses and coarsened exact matching were used to determine the independent difference in the incidence of ureteral injury between the 2 groups. Multivariate models were also used to determine the independent association between postoperative complications associated with ureteral injury.

Results: Of a total of 94 526 colectomies, 33 092 (35%) were completed laparoscopically. Ureteral injury occurred in a total of 585 patients (0.6%). The crude incidence in the open group was higher than that in the laparoscopic group (0.66% versus 0.53%, $P = .016$). CEM produced 14 630 matching pairs. Matched analysis showed the likelihood of ureteral injury after laparoscopic colectomy to be 30% less than after open colectomy (odds ratio, 0.70; 95% confidence interval, 0.51–0.96). Patients with ureteral injury were independently more likely to have septic complications and have longer lengths of hospital stay than those without ureteral injury.

Conclusion: Laparoscopic colectomy is associated with a lower incidence of intraoperative ureteral injury when compared with open procedures. Ureteral injury leads to significant postoperative morbidity even if identified and repaired during the colectomy.

Key Words: Ureteral injury, Colon resection, Iatrogenic injury, Laparoscopic surgery, Coarsened exact matching.

INTRODUCTION

Ureteral injury (UI) is a devastating complication of colon surgery with an incidence ranging from 0.2% to 1.5%.[1–4] UIs are associated with an increase in hospital stay of about 4 days and additional costs of $31 000. It is unclear whether UI has a higher incidence after laparoscopic colectomy (LC) or open colectomy (OC). Palaniappa et al,[3] in a recent single-institution retrospective study, showed LC to be associated with a higher incidence of UI (0.66% versus 0.15%, $P = .007$). Halabi et al[4] recently used a national database to study factors associated with UI after colon surgery and found LC to be a protective factor (odds ratio [OR], 0.91).

UI after colectomy is infrequent and therefore difficult to study. Randomized controlled trials on this topic may not be feasible. Large databases offer enough power to perform multivariate analysis. However, multivariate analysis alone may not be adequate. There may be an inherent difference in the patient population selected for LC versus OC dependent on the disease severity. In lieu of a large multicenter randomized controlled trial, a well-matched large database analysis would provide the highest level of evidence. We aimed to use a national surgical database to compare the incidence of intraoperative UI after LC versus OC after matching the 2 patient populations on disease severity. We

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also aimed to determine the risk-adjusted morbidity and mortality rates associated with UI after colectomy.

METHODS

We analyzed the National Surgical Quality Improvement Program (NSQIP) database for the years 2005–2010. The NSQIP database, maintained by the American College of Surgery, collects surgical data from participating centers throughout the United States.[5] It includes preoperative risk factors, intraoperative variables, and 30-day postoperative mortality and morbidity rates for major surgical procedures.

The NSQIP provides 3 types of procedure variables using Current Procedural Terminology codes: "principal procedure," which—as the name suggests—is the main surgical procedure performed by the primary operating team; "other procedures" are operative procedures apart from the principal procedure performed by the same operating team; and "concurrent procedures" are additional surgical procedures performed by a different operating team with the patient under the same anesthetic. Each patient has 1 principal procedure and can have up to 10 other procedures and 10 concurrent procedures.

We selected all patients undergoing LC or OC as the principal procedure. All total and partial colectomies were included. Patients who had LC converted to OC were excluded from the main analysis because it is not possible to determine whether UI occurred during the laparoscopic part or the open part of the operation. Conversions were identified by a principal procedure code of open surgery and a concurrent code for laparoscopic surgery, or vice versa. We identified patients with UI by other procedure and concurrent procedure codes involving repair or drainage procedures on the ureters. A list of Current Procedural Terminology codes with their descriptions is provided in **Appendix 1**.

To compare the independent incidence of UI between LC and OC, we applied 2 different statistical techniques. First, we performed a standard multivariate logistic regression analysis adjusting for demographic variables, which included age, gender, race, body mass index, year of operation; clinical characteristics including comorbid conditions, American Society of Anesthesiologists (ASA) classification, diagnosis, probability of death, and probability of morbidity; and operative characteristics including partial versus total colectomy, wound class, emergency versus elective surgery, ureteral stent placement, and operative time

In addition, we used coarsened exact matching (CEM) to match patients who underwent LC with patients undergoing OC on preoperative variables and severity of illness. CEM is a relatively new technique of matched analysis and is considered superior to other matching techniques (eg, propensity score matching) because it uses monotonic imbalance bounding (reducing the balance in 1 factor has no effect on other factors), therefore eliminating the need for multiple iterations of matching and balance assessment.[6] CEM involves temporarily categorizing (coarsening) data, performing exact matching, and then running an analysis on the uncoarsened, matched data. We used a 1:1 matching criterion. After CEM, conditional logistic regression was used to account for the loss of independence between the 2 groups as a result of the matching process.

Patients were matched on age, gender, race, emergency versus elective procedure, diagnosis, ASA class, type of surgery, predicted probability of death, and predicted probability of morbidity. These "predicted" variables are provided in the NSQIP and are derived by logistic regression analysis on patients' preoperative characteristics. These are measures of severity, and matching on these probabilities provides for adequate comparative-effectiveness research. Even though patients in this sample are not randomly assigned to either group, this matching scheme virtually eliminates bias in technique selection (open versus laparoscopic) and provides for 2 equal groups of patients for adequate comparison.

We also wished to determine the independent association of UI with postoperative morbidity and death. For this, we performed separate multivariate logistic regression analyses with each major postoperative complication as a dichotomous outcome variable. Predictor variables in the model included "ureteral injury" and all the previously mentioned pre-existing and operative variables.

Because conversions were excluded from the main analysis, there is a potential for selection bias to occur in favor of LC. It is possible that an LC was converted to open just because of a UI, and leaving these patients out or including them in the open group could potentially bias the results in favor of LC. However, including these patients in the LC group is also not ideal because UI could have occurred during the open part of the procedure; this would bias the results in favor of OC. We therefore excluded converted patients from our main analysis and conducted a sensitivity analysis including all conversions in the laparoscopic group. Considering "intention-to-treat" analysis, we considered this to be appropriate. It is expected that conversions would be few in number and their overall influence on the difference between the incidence of UI after LC and OC would be minimal. In addition, because the sensitivity analysis has an opposing bias to the main analysis, we can be assured of the minimal influence of this bias if the results from both analyses favor the same procedure.

RESULTS

Of the total 1.3 million major surgical procedures in the NSQIP (2005–2010), there were 95 443 colectomies (7%). After we excluded 906 "laparoscopic converted to open" procedures (0.9%), there were 94 526 procedures available for analysis. Of these, 61 434 (65%) were performed open and 33 092 (35%) were completed laparoscopically.

Table 1 shows a bivariate comparison of pre-existing and operative characteristics between the groups. Patients in the open group were more likely to be older (48 years versus 46 years), female (53% versus 47%), of minority race (black race, 10% versus 7%), obese (body mass index >35 kg/m^2, 14% versus 12%); have a higher ASA class (ASA class 4, 13% versus 3%); undergo an emergent procedure (23% versus 4%); and have higher probabilities of death (25% versus 15%) and morbidity (2.5% versus 0.4%) (all P values $< .001$). An attending surgeon was present in all cases. The rate of a preoperative diagnosis of diverticulitis was higher in the laparoscopic group (23% versus 15%), and partial resections were more common in the laparoscopic group (93% versus 73%) ($P < .001$).

UIs occurred in a total of 585 cases (0.6%). The incidence in the open group was slightly higher than that in the laparoscopic group (0.66% versus 0.53%, $P = .016$). **Table 2** shows an unadjusted comparison of major complications and deaths between the 2 groups. Patients in the laparoscopic group had lower rates of complications and death. Surgical-site infection showed the highest incidence (9% in the open group versus 6% in the laparoscopic group), followed by return to the operating room (9% versus 5%), sepsis (6% versus 3%), and reintubation (4.5% versus 1.3%). The crude mortality rate was 7.3% in the open group versus 1.1% in the laparoscopic group ($P < .001$).

Multivariate logistic regression analysis showed LC to be 39% less likely to be associated with UIs (OR, 0.6; 95% confidence interval [CI], 0.49–0.75). CEM produced 14 630 matching pairs. After matching, the imbalance between the 2 groups measured by the L1 distance was 0.02. The L1 distance provides for a global multivariable measure of imbalance between 2 groups. It ranges from 0 to 1, where 0 equals perfect global balance. Even after matching, the incidence of UI was higher in the OC group than in the LC group (0.71% versus 0.50%, $P = .027$). Conditional logistic regression showed the likelihood of having a UI to be 30% less for LC versus OC (OR, 0.70; 95% CI, 0.51–0.96) (**Figure 1**). Sensitivity analysis with conversions included in the LC group showed similar results (OR, 0.75; 95% CI, 0.56–0.99).

UI was associated with several complications. **Figure 2** shows the incidence of complications among patients who had UIs. **Table 3** shows independent factors associated with UI. Patients with UIs were more likely to have septic complications and have longer lengths of stay.

DISCUSSION

UI after colectomy is infrequent; however, the consequences are dire. In our analysis of a national surgical database, the overall incidence of identified UIs during colectomy was low, at 0.6%. Colon resection is one of the most common procedures performed in the United States, with >200 000 colectomies performed per year.[7] Therefore 1200 to 2000 patients are estimated to have iatrogenic UIs during colon resection each year. A recent analysis of a national database showed an increasing incidence of UI after colectomy from 0.23% in 2001 to 0.38% in 2010. Patients with UI have a myriad of short-term and long-term complications, including sepsis, renal failure, return to the operating room, ureterocutaneous fistulae, strictures, and even the need for a nephrectomy.[1,8–10] In our analysis, even after we adjusted for other covariates, UI was associated with systemic and septic complications. Our analysis only accounts for UIs identified during the operation. Studies have shown that up to 40% of UIs related to colectomy are diagnosed postoperatively.[10] UIs diagnosed late are associated with a higher number of complications, number of procedures, and mortality rate.[8–10]

Regardless of the procedure performed, diligence while dissecting in proximity to the ureters is paramount. Techniques that decrease the likelihood of UI should be preferred.[2] In our analysis, after we adjusted for preoperative and intraoperative characteristics, LC was associated with a 30% lower likelihood of UI. In theory, 2 fewer patients would have a UI for every 1000 colectomies performed laparoscopically.

Our results are in contrast to a recent study in which LC was associated with a higher incidence of UI.[3] That study, however, being a single-institution study, was limited by the numbers. Because only 14 patients had a UI, multivariate analyses were not possible and conclusions were based on crude results. Patients receiving OC and LC differ

Table 1.
Bivariate Comparisons of Pre-Existing and Intraoperative Factors Between Patients Undergoing Laparoscopic and Patients Undergoing Open Colectomy

Variable	Total (N = 94 526)	Open (n = 61 434)	Laparoscopic (n = 33 092)	*P* Value
Age [mean (SD)] (y)	47.19 (15.74)	48.01 (15.84)	45.69 (15.45)	<.001
Age category [n (%)]				
0–15 y	3638 (3.85)	2212 (3.6)	1426 (4.31)	<.001
16–25 y	5358 (5.67	3307 (5.38)	2051 (6.20)	
26–35 y	12 057 (12.76)	7553(20.33)	4504 (13.61)	
36–45 y	20 244 (21.42)	12 492 (20.88)	7752 (23.43)	
46–55 y	21 908 (23.18)	14 039 (22.85)	7869 (23.78)	
56–65 y	18 977 (20.08)	12 826 (20.88)	6151 (18.59	
66–75 y	12 344 (13.06)	9005 (14.67)	3339 (10.09)	
Race [n (%)]				
White	73 946 (78.23)	47 390 (77.14)	26 556 (80.25)	<.001
Black	8657 (9.16)	6283 (10.23)	2374 (7.17)	
Hispanic	2029 (2.15)	1328 (2.16)	701 (2.12)	
Other	3370 (3.57)	1952 (3.18)	1418 (4.29)	
Unknown	6524 (6.90)	4481 (7.29)	2043 (6.17)	
Female gender [n (%)]	49 545 (52.54)	32 305 (52.67)	17 240 (47.33)	.266
BMI [n (%)]				
≤25 kg/m^2	33 136 (35.67)	22 284 (37.11)	10 852 (33.05)	<.001
25–30 kg/m^2	30 448 (32.78)	18 759 (31.24)	11 689 (35.59)	
30–35 kg/m^2	17 124 (18.43)	10 695 (17.81)	6429 (19.58)	
>35 kg/m^2	12 181 (13.11)	8311 (13.84)	3870 (11.78)	
Admission year [n (%)]				
2005	2751 (2.91)	2043 (3.33)	708 (2.14)	<.001
2006	9141 (9.67)	6431 (10.47)	2710 (8.19)	
2007	16 611 (17.57)	11 207 (18.24)	5404 (16.33)	
2008	20 064 (21.23)	13 210 (21.50)	6854 (20.71)	
2009	22 996 (24.33)	14 728 (23.97)	8268 (24.98)	
2010	22 963 (24.29)	13 815 (22.49)	9148 (27.64)	
Diagnosis [n (%)]				
Malignancy	33 079 (34.99)	21 100 (34.35)	11 979 (36.20)	<.001
Ulcerative colitis	3176 (3.36)	1949 (3.17)	1227 (3.71)	
Ischemic colitis	727 (0.77)	682 (1.11)	45 (0.14)	
Diverticulitis	16 645 (17.61)	9054 (14.74)	7591 (22.94)	
Other	40 899 (43.27)	28 649 (46.63)	12 250 (37.02)	
ASA[a] class [n (%)]				
1	2980 (3.15)	1488 (2.42)	1492 (4.51)	<.001
2	42 216 (44.66)	23 058 (37.53)	19 158 (57.89)	
3	39 471 (41.76)	28 013 (45.60)	11 458 (34.62)	

Table 1.
Continued

Variable	Total (N = 94 526)	Open (n = 61 434)	Laparoscopic (n = 33 092)	*P* Value
4	8996 (9.52)	8049 (13.10)	947 (2.86)	
5	775 (0.82	757 (1.23)	18 (0.05)	
Not assigned	88	69	19	
Emergency surgery: yes [n (%)]	16 649 (17.61)	15 477 (25.19)	1172 (3.54)	<.001
Partial resection: yes [n (%)]	75 657 (80.04)	44 920 (73.12)	30 737 (92.88)	<.001
Ureteral stent: yes [n (%)]	5000 (5.29)	3066 (4.99)	1934 (5.84)	<.001
Probability of morbidity [mean (SD)]	1.82% (15.8)	2.5% (18.8)	0.4% (7.7)	<.001
Probability of death [mean (SD)]	21.5% (15.9)	25.0% (18.9)	15.1% (7.8)	<.001
Wound class [n (%)]				
Clean				
Clean-contaminated	69 717 (73.8)	40 946 (66.7)	28 771 (86.9)	<.001
Contaminated	11 392 (12.1)	8346 (13.6)	3046 (9.2)	
Dirty	13 321 (14.1)	12 092 (19.7)	1229 (3.71)	
Not assigned	96 (0.10)	50 (0.08)	46 (0.14)	<.001
Operative time [n (%)]				
<1 h	–	–	–	
1–3 h	64 801 (68.55)	43 319 (70.51)	21 482 (64.92)	<.001
3–5 h	23 684 (25.06)	14 151 (23.03)	9533 (28.81)	
5–8 h	5336 (5.65)	3412 (5.55)	1924 (5.81)	
>8 h	691 (0.73)	540 (0.88)	151 (0.46)	
Unknown	13 (0.01)	12 (0.02)	1 (0)	

[a]ASA = American Society of Anesthesiologists.

from each other in several ways, including demographic characteristics, disease severity, diagnosis, and intraoperative characteristics. These can confound the association between operative technique and the occurrence of UI and need to be adjusted for. Using a national database of several centers across the United States, we were able to identify 585 colectomy-related UIs. This allowed us to appropriately adjust for preoperative and intraoperative confounders and therefore provide more reliable estimates. Halabi et al,[4] in a recent national database study, also found a protective effect of LC when compared with OC. However, because determining the difference in the incidence of UI after LC versus OC was not the main objective of their study, they did not match patients based on injury severity. We used robust matching techniques that, in lieu of a multicenter randomized controlled trial, provide for the highest level of evidence.

Several studies have described the various advantages of LC over OC. LC provides for less blood loss; an earlier return of bowel function; a lower analgesic requirement; fewer wound infections; fewer intra-abdominal abscesses; fewer cardiovascular, respiratory, gastrointestinal, and overall complications; shorter lengths of hospital stay; and even fewer deaths.[7,11–17] Even though operative times are longer and operating room costs are higher, the overall hospital costs are lower.[14,18] The use of LC has grown substantially over the past 5 years. In the years 1996 to 2004, only 2% to 6% of colectomies were performed laparoscopically, but these rates increased to 15% in 2008 and 31% in 2009.[19,20] In our study this rate of increase was very similar, at 25% in 2005 and 40% in 2010. As more surgeons are accustomed to the techniques, the outcomes are expected to improve. In our study, the rates of UI after LC declined from 0.9% to 0.5% from 2005 to 2010.

An important limitation is that we were only able to study UIs that were identified intraoperatively. As mentioned earlier, up to 40% of colectomy-related UIs are identified postoperatively.[10] Data regarding postoperatively diag-

Table 2.
Bivariate Comparison Complications and Deaths Associated With Laparoscopic Versus Open Colectomy

Outcome	Total [n (%)]	Open [n (%)]	Laparoscopic [n (%)]	*P* Value[a]
Ureter injury	585 (0.62)	408 (0.66)	177 (0.53)	.016
Superficial SSI[b]	7662 (8.11)	5670 (9.23)	1992 (6.02)	<.001
Deep SSI	1504 (1.59)	1215 (1.98)	289 (0.87)	<.001
Organ space infection	3944 (4.17)	3022 (4.92)	922 (2.79)	<.001
Pneumonia	3748 (3.97)	3255 (5.30)	493 (1.49)	<.001
Reintubation	3196 (3.38)	2758 (4.49)	438 (1.32)	<.001
PE[b]	758 (0.8)	608 (0.99)	150 (0.45)	<.001
Renal insufficiency	909 (0.96)	751 (1.22)	158 (0.48)	<.001
ARF[b]	1089 (1.15)	970 (1.58)	119 (0.36)	<.001
UTI[b]	3626 (3.84)	2773 (4.51)	853 (2.58)	<.001
Cardiac arrest	887 (0.94)	788 (1.28)	99 (0.30)	<.001
MI[b]	649 (0.69)	530 (0.86)	119 (0.36)	<.001
Sepsis	4855 (5.14)	3940 (6.41)	915 (2.77)	<.001
Shock	3417 (3.61)	3013 (4.90)	404 (1.22)	<.001
Return to OR[b]	7017 (7.42)	5488 (8.93)	1529 (4.62)	<.001
LOS[b] >7 d	39 931 (42.29)	33 214 (54.15)	6717 (20.31)	<.001
Death	4034 (5.13)	3718 (7.31)	315 (1.14)	<.001

[a]Chi-square test.

[b]ARF = acute renal failure; LOS = length of stay; MI = myocardial infarction; OR = operating room; PE = pulmonary embolism; SSI = surgical-site infection; UTI = urinary tract infection.

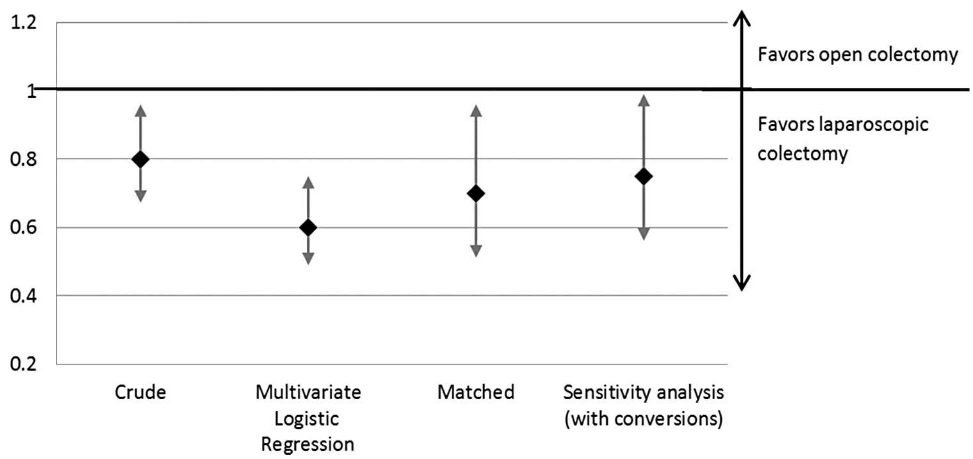

Figure 1. Odds ratios and 95% confidence intervals of ureteral injury after laparoscopic versus open colectomy. (Reference is open colectomy.)

nosed UIs were not collected as part of these data. It is hard to determine how missing these delayed UIs would affect the results of our analysis. It is not known whether a UI is more likely to be missed with laparoscopic or open procedures. Because no large database collects information on UI as a postoperative complication, this issue is difficult to study. We believe that the missed UIs would most likely be equal with LC or OC. A large multicenter study over the span of several years will need to be performed to sufficiently assess this question. Nonethe-

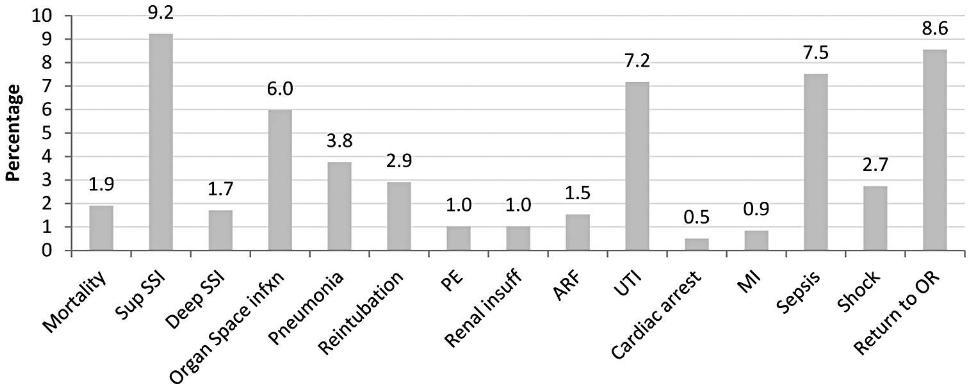

Figure 2. Incidence of adverse outcomes among patients with ureteral injury after colectomy. ARF = acute renal failure; infxn = infection; insuff = insufficiency; MI = myocardial infarction; OR = operating room; PE = pulmonary embolism; SSI = surgical-site infection; Sup = superficial; UTI = urinary tract infection.

Table 3.
Independent Outcomes Associated With Ureteral Injury After Colectomy

Factor	Ureteral Injury [n (%)]		Adjusted OR[a]	95% CI[a]
	No	Yes		
Organ space infection	3909 (4.16)	35 (5.98)	1.64	1.157–2.314
Urinary tract infection	3584 (3.82)	42 (7.18)	2.21	1.602–3.044
Sepsis	4811 (5.12)	44 (7.52)	1.70	1.243–2.327
Return to operating room	6967 (7.42)	50 (8.55)	1.42	1.051–1.921
Length of stay >7 d	29 634 (42.24)	297 (50.86)	1.70	1.411–2.043
Death	4025 (5.15)	9 (1.91)	0.66	0.327–1.322

[a]CI = confidence interval; OR = odds ratio.

less, our study pertains to only UIs identified intraoperatively, and it is left to the reader's discretion to extrapolate these results to encompass postoperatively identified UIs or not. In addition, our analysis does not account for planned ureteral resections that may occur in some cases, such as en bloc resection for tumors. However, we believe that these cases would be too few in number to significantly affect the analysis. Moreover, even though we used robust statistical techniques, our analysis is limited by the data available in this retrospective study. We were unable to match on clinical factors such as prior abdominal surgery, tumor size, or urinary tract involvement by tumor. These factors may have influenced a surgeon's decision to perform LC versus OC. In addition, there is an issue of generalizability. Data for this study have been derived from >95 000 operative cases from >200 centers across the United States participating in the NSQIP. These include both academic and nonacademic centers. Even though this is the largest study to date on this topic, the sample is not derived from a probability sample and is therefore not nationally representative.

Preoperative stent placements comprise another issue. Procedure codes for transurethral ureteral stent placements concurrently with colectomy likely represent prophylactic stent placements. Stent placements in our analyses were not associated with a higher or lower incidence of UI. However, our study was not designed to test this hypothesis, and readers should not draw such conclusions. The addition of "stents" placed in our model was done merely to adjust for confounding measures.

CONCLUSIONS

In a national surgical database, the overall incidence of identified UIs during colectomy was low, at 0.6%. However, patients with UI have devastating consequences, with increased in-hospital complications and prolonged hospital

Appendix 1.
CPT Codes, With Descriptions, Used in Analysis

Description	CPT[a] Code
Laparoscopic colectomy	
Laparoscopic colectomy, partial, with anastomosis	44204
Laparoscopic colectomy, partial, with removal of terminal ileum with ileocolostomy	44205
Laparoscopic colectomy, partial, with end colostomy and closure of distal segment	44206
Laparoscopic colectomy, partial, with coloproctostomy	44207
Laparoscopic colectomy, partial, with coloproctostomy with colostomy	44208
Laparoscopic colectomy, total, without proctectomy with ileostomy or ileoproctostomy	44210
Laparoscopic colectomy, total, with proctectomy with ileoanal anastomosis, creation of ileal reservoir, with loop ileostomy	44211
Laparoscopic colectomy, total, with proctectomy, with ileostomy	44212
Open colectomy	
Colectomy, partial, with anastomosis	44140
Colectomy, partial, with skin level cecostomy or colostomy	44141
Colectomy, partial, with end colostomy and closure of distal segment	44143
Colectomy, partial, with resection, with colostomy or ileostomy and creation of mucofistula	44144
Colectomy, partial, with coloproctostomy	44145
Colectomy, partial, with coloproctostomy, with colostomy	44146
Colectomy, partial, abdominal and transanal approach	44147
Colectomy total, abdominal without proctectomy with ileostomy or ileoproctostomy	44150
Colectomy total, abdominal, without proctectomy with ileostomy or ileoproctostomy, with continent ileostomy	44151
Colectomy total, abdominal, with proctectomy with ileostomy	44155
Colectomy total, abdominal, with proctectomy with ileostomy, with continent ileostomy	44156
Colectomy total, abdominal, with proctectomy with ileostomy, with ileoanal anastomosis	44157
Colectomy total, abdominal, with proctectomy, with ileoanal anastomosis, creation of ileal reservoir, with loop ileostomy	44158
Colectomy, partial, with removal of terminal ileum with ileocolostomy	44160
Repair or drainage procedures on ureter—signifying ureteral injury	
Ureteropyelostomy, anastomosis of ureter and renal pelvis	50740
ureterocalycostomy, anastomosis of ureter to renal calyx	50750
Ureteroureterostomy	50760
Transureteroureterostomy	50770
Ureteroneocystostomy	50780
Ureteroneocystostomy with extensive ureteral tailoring	50783
Ureteroneocystostomy with vesico-psoas hitch or bladder flap	50785
Ureteroenterostomy	50800
Ureterosigmoidostomy with creation of sigmoid bladder and establishment of abdominal or perineal colostomy including intestine anastomosis	50810
Ureterocolon conduit, including intestine anastomosis	50815
Ureteroileal conduit, including intestine anastomosis	50820
Continent diversion, including intestine anastomosis using any segment of small or large intestine	50825
Replacement of all or part of ureter by intestine segment	50840
Cutaneous appendicovesicostomy	50845
Ureterostomy	50860
Ureterorrhaphy	50900
Laparoscopic ureteroneocystostomy with cystoscopy and ureteral stent placement	50947
Laparoscopic ureteroneocystostomy without cystoscopy and ureteral stent placement	50948
Unlisted laparoscopy procedure on ureter	50949
Cystourethroscopy, with insertion of ureteral guide wire through kidney to establish a percutaneous nephrostomy retrograde	52334
Nephrostomy, nephrotomy with drainage	50040

[a]AMA, CPT 2013 Professional Edition (Current Procedural Terminology), American Medical Association, 2012.

stays. Extreme caution must be practiced while dissecting around the ureters. Techniques to avoid intraoperative UI would save significant morbidity and cost. In our analysis LC was associated with a slightly lower incidence of UI when compared with OC. Our results favor the uptake of laparoscopic procedures for colon resection.

References:

1. Assimos DG, Patterson LC, Taylor CL. Changing incidence and etiology of iatrogenic ureteral injuries. *J Urol*. 1994;152: 2240–2246.

2. Larach SW, Patankar SK, Ferrara A, Williamson PR, Perozo SE, Lord AS. Complications of laparoscopic colorectal surgery. Analysis and comparison of early vs. latter experience. *Dis Colon Rectum*. 1997;40:592–596.

3. Palaniappa NC, Telem DA, Ranasinghe NE, Divino CM. Incidence of iatrogenic ureteral injury after laparoscopic colectomy. *Arch Surg*. 2012;147:267–271.

4. Halabi WJ, Jafari MD, Nguyen VQ, et al. Ureteral injuries in colorectal surgery: an analysis of trends, outcomes, and risk factors over a 10-year period in the United States. *Dis Colon Rectum*. 2014;57:179–186.

5. American College of Surgeons, National Surgical Quality Improvement Program. Available at: http://site.acsnsqip.org/. Accessed January 30, 2014.

6. Blackwell M, Iacus S, King G, Porro G. CEM: coarsened exact matching in Stata. *Stata J*. 2010;9:524–546.

7. Cone MM, Herzig DO, Diggs BS, et al. Dramatic decreases in mortality from laparoscopic colon resections based on data from the Nationwide Inpatient Sample. *Arch Surg*. 2011;146:594–599.

8. Fry DE, Milholen L, Harbrecht PJ. Iatrogenic ureteral injury. Options in management. *Arch Surg*. 1983;118:454–457.

9. Gangai MP, Agee RE, Spence CR. Surgical injury to ureter. *Urology*. 1976;8:22–27.

10. Selzman AA, Spirnak JP. Iatrogenic ureteral injuries: a 20-year experience in treating 165 injuries. *J Urol*. 1996;155:878–881.

11. Veldkamp R, Kuhry E, Hop WC, et al. Laparoscopic surgery versus open surgery for colon cancer: short-term outcomes of a randomised trial. *Lancet Oncol*. 2005;6:477–484.

12. Buunen M, Veldkamp R, Hop WC, et al. Survival after laparoscopic surgery versus open surgery for colon cancer: long-term outcome of a randomised clinical trial. *Lancet Oncol*. 2009; 10:44–52.

13. Bartels SA, Gardenbroek TJ, Ubbink DT, Buskens CJ, Tanis PJ, Bemelman WA. Systematic review and meta-analysis of laparoscopic versus open colectomy with end ileostomy for non-toxic colitis. *Br J Surg*. 2013;100:726–733.

14. Dwivedi A, Chahin F, Agrawal S, et al. Laparoscopic colectomy vs. open colectomy for sigmoid diverticular disease. *Dis Colon Rectum*. 2002;45:1309–1314; discussion 1314–1315.

15. Guller U, Jain N, Hervey S, Purves H, Pietrobon R. Laparoscopic vs open colectomy: outcomes comparison based on large nationwide databases. *Arch Surg*. 2003;138:1179–1186.

16. Kemp JA, Finlayson SR. Outcomes of laparoscopic and open colectomy: a national population-based comparison. *Surg Innov*. 2008;15:277–283.

17. Mbadiwe T, Obirieze AC, Cornwell EE III, Turner P, Fullum TM. Surgical management of complicated diverticulitis: a comparison of the laparoscopic and open approaches. *J Am Coll Surg*. 2013;216:782–788; discussion 788–790.

18. Koh FH, Tan KK, Tsang CB, Koh DC. Laparoscopic versus an open colectomy in an emergency setting: a case-controlled study. *Ann Coloproctol*. 2013;29:12–16.

19. Kemp JA, Finlayson SR. Nationwide trends in laparoscopic colectomy from 2000 to 2004. *Surg Endosc*. 2008;22:1181–1187.

20. Bardakcioglu O, Khan A, Aldridge C, Chen J. Growth of laparoscopic colectomy in the United States: analysis of regional and socioeconomic factors over time. *Ann Surg*. 2013;258:270–274.