GYNECOLOGY

Delayed recognition of lower urinary tract injuries following hysterectomy for benign indications: A NSQIP-based study

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OBJECTIVE: To describe the incidence of and factors associated with lower urinary tract complications recognized in the immediate postoperative period following hysterectomy for benign gynecologic indications using the NSQIP (National Surgical Quality Improvement Program) database.

METHODS: Patients who underwent hysterectomy for benign indications from 2014 through 2016 were identified in the NSQIP database using Current Procedural Terminology codes and International Classification of Diseases codes. Patient demographics, preoperative comorbidities, ASA classification system scores, and total operating time were collected. Data on 30-day postoperative complication rates, including rates of reoperation and readmission, were also captured. Genitourinary complications were defined as ureteral obstruction, ureteral fistula, and bladder fistula.

RESULTS: A total of 45,139 patients met inclusion criteria during the study period. Mean age and body mass index were 31 ± 11years and 32 ± 8 kg/m^2. The majority of patients were white (66%), had an ASA class of 2 (67%), and had no major medical comorbidities (68%). The most commonly performed primary surgery was laparoscopic hysterectomy (43%), followed by abdominal hysterectomy (27%). The incidence of any lower urinary tract complication was 0.2% (95% confidence interval, 0.19−0.28): 55 ureteral obstructions (0.1%, 95% confidence interval, 0.09−0.16), 33 ureteral fistulae (0.07%, 95% confidence interval, 0.05−0.1), and 28 bladder fistulae (0.06%, 95% confidence interval, 0.04−0.09). In a multivariable logistic regression model, black race (adjusted odds ratio, 1.90; 95% confidence interval, 1.20−2.96), endometriosis (adjusted odds ratio, 2.29; 95% confidence interval, 1.44−3.52), and prior abdominal surgery (adjusted odds ratio, 1.53; 95% confidence interval, 1.01−2.28) remained significantly associated with the occurrence of any lower urinary tract complication recognized in the immediate 30-day postoperative window.

CONCLUSION: Lower urinary tract complications recognized in the immediate postoperative period following hysterectomy for benign gynecologic disease are rare, with ureteral obstruction being the most commonly reported complication. The risk of these complications may be higher in patients who identify as black, had prior abdominal surgery, and/or have a diagnosis of endometriosis.

Key words: Complications, hysterectomy, lower urinary tract

Iatrogenic lower urinary tract (LUT) injury at the time of hysterectomy for benign indications is rare, with reported rates ranging from 0.3 to 1.3%.[1−4] The risk of these complications varies greatly, depending on the route of surgery, the indication for surgery, and surgeon technique. Prior pelvic surgery and conditions that distort pelvic anatomy, such as endometriosis and uterine fibroids, have been associated with an increased risk of urologic injury at the time of hysterectomy.[5,6] Other factors, such as obesity, increased blood loss, and longer operative times, have also been linked to a higher risk of injury.[7,8] LUT injury is also a recognized complication of surgery for pelvic organ prolapse and urinary incontinence.[2,9] However, up to 75% of urinary tract injuries at the time of hysterectomy are reported to occur in patients without any identifiable risk factors.[7,9]

Varying mechanisms can contribute to LUT injuries. Direct ureteral injury, including crush injury, transection, ligation, and/or kinking, can occur. Indirect injury usually involves the spread of thermal energy, which often leads to delayed injuries. While intraoperative identification allows for prompt management, studies have shown that 62−87% of injuries go unnoticed and are recognized in the postoperative period.[3,4,10] The long-term sequelae of unrecognized LUT injuries include the development of genitourinary fistulae, ureteral obstruction, and renal failure, all of which can lead to significant morbidity and, sometimes, mortality.[11]

Although previous studies have described factors that increase risk for LUT injury at the time of hysterectomy, few have focused on the recognition of LUT complications in the immediate postoperative period. The objective of this study is to describe the incidence of and factors associated with LUT complications recognized in the immediate postoperative period following hysterectomy performed for benign gynecologic indications using the American College of Surgeons National Surgical Quality Improvement Program (NSQIP) database.

Materials and Methods

This was a retrospective cohort study using data from the NSQIP database from 2014 through 2016. Studies using the NSQIP database are considered exempt by our institutional review board. The NSQIP database captures data on more than 150 perioperative variables, including preoperative comorbidities, intraoperative variables, and 30-day mortality and morbidity outcomes for multiple surgical procedures. Data from more than 600

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AJOG at a Glance

Why was this study conducted?

This study was conducted to describe the incidence of and factors associated with lower urinary tract complications recognized in the immediate postoperative period following hysterectomy for benign gynecologic indications using a large national database.

Key findings

The incidence of a lower urinary tract complication identified in the immediate postoperative period was low at 0.2%. We found that black race, prior abdominal surgery, and endometriosis were factors associated with these kinds of complications.

What does this add to what is known?

Our study is one of the first to describe the incidence of and factors associated with lower urinary tract injury in the setting of hysterectomy for benign indications.

participating hospitals are collected by certified surgical clinical reviewers and data quality is maintained by standardizing training of all reviewers as well as intermittent interrater reliability audits of the participating sites.[12] Data at each site are obtained from medical chart review as well as direct contact with patients. NSQIP reports a 95% success rate in capturing outcomes on all cases within the database. The database uses Current Procedural Terminology (CPT) codes and the International Classification of Diseases, 9th Revision codes to report on all procedures. Patients younger than 18 years old are excluded from the database. In addition to the "principal operative procedure," "concurrent procedures" as well as "other procedures" were also collected. "Concurrent procedures" are defined by NSQIP as those performed during the same surgical case but by a different surgical team, while "other procedures" are defined as additional surgical procedures performed by the primary surgical team.

Since 2014, NSQIP has collected targeted data specific to hysterectomy. These data include parity, presence and location of endometriosis, history of abdominal and pelvic surgery, presence of pelvic inflammatory disease with or without tubo-ovarian abscess, uterine weight, and presence and location of neoplastic tissue. It also contains information about development of bowel obstruction, urinary tract injury, and fistula formation. This dataset may be combined with the general NSQIP dataset using a unique numerical identifier assigned to each patient.

The Figure shows how the study population was identified. All patients included in the NSQIP Hysterectomy targeted dataset between 2014 and 2016 were identified, and these files were linked by "CASEID," which is a unique identifier to the regular NSQIP dataset. Patients who were missing data were excluded. Patients with a gynecologic malignancy were excluded using the "Gynecologic Cancer Case" variable in the NSQIP Hysterectomy targeted data, which indicates whether or not the patient underwent surgery for gynecologic cancer. Patients who underwent radical hysterectomy; who underwent bowel resection, lymphadenectomy, or tumor debulking in conjunction with their hysterectomy; or who did not undergo hysterectomy (ie, underwent myomectomy, oophorectomy, or salpingectomy alone) were also excluded from the study population. The following CPT codes for procedures associated with the above diagnoses were excluded: 51925, 58140, 58145, 58146, 58200, 51925, 58210, 58240, 58285, 58528, 58940, 58950, 58545, 58546, 58943, and 58951-6.

Hysterectomies were categorized as abdominal, vaginal, laparoscopic, or laparoscopic-assisted vaginal based on the following CPT codes: abdominal hysterectomy (58150, 58152, 58180), laparoscopic hysterectomy (58541–58544, 58570–58573), vaginal hysterectomy (58260, 58262, 58263, 58267, 58270, 58290–58294), and laparoscopic-assisted vaginal hysterectomy (58550, 58552–58554). Data regarding concurrent urogynecologic procedures for pelvic organ prolapse and/or stress urinary incontinence as well as concurrent cystoscopy were also collected.

Once patients were identified, the database was queried for demographic data such as age, body mass index (BMI), race, parity, ASA class, intraoperative diagnosis of endometriosis or pelvic inflammatory disease, and previous abdominal and pelvic surgery. Preoperative hematocrit, uterine weight, operative time, length of hospital stay, 30-day postoperative events, and readmission and reoperation data were also collected. Thirty-day-postoperative events included transfusion intraoperatively or within 72 hours of surgery, bladder fistula, ureteral fistula, ureteral obstruction, renal insufficiency or failure, urinary tract infection, venous thromboembolic disease, pneumonia, reintubation, sepsis or septic shock, wound dehiscence, myocardial infarction or cardiac arrest, cerebrovascular accident, and deep or organ space infection. All preexisting clinical conditions were defined as being present within 1–6 months prior to surgery. Any patient with missing data was excluded, with the exception of patients with missing readmission data, with the number of missing reported in Table 2.

Patients were stratified into 2 groups based on the presence or absence of a LUT complication identified in the 30-day postoperative window. LUT complications were defined as ureteral obstruction, ureteral fistula, and bladder fistula. The number of days after the index surgery that the LUT injury was recognized was also collected.

The primary outcome was the presence or absence of a LUT injury identified in the 30-day-postoperative window, and this was analyzed as a dichotomous variable. Patients with any missing data were excluded from the

analysis. Descriptive statistics are reported as means with standard deviations. Pairwise comparison was performed using Student t test where appropriate for continuous variables and χ^2 and Fisher exact tests for categorical variables where appropriate. A P value of $<.05$ was considered statistically significant. Multivariable logistic regression models were fit to evaluate factors associated with LUT complications while adjusting for potential confounders. For the multivariable logistic regression model, factors that were deemed clinically relevant or those variables that were strongly associated with LUT injury on univariate analyses were included. Collinearity testing was performed on the variables in the final regression model. All data were analyzed with R 3.4.1.

Results

A total of 72,607 patients were included in the hysterectomy targeted dataset during the study period. Our final cohort of patients undergoing hysterectomy for benign indications consisted of 45,139 patients (Figure). Table 1 displays patient characteristics for all patients who met inclusion criteria for the study (n = 45,139), those who experienced a LUT injury recognized in the immediate postoperative period (n = 105), and those who did not (n=45,034). Mean age was 31.0 ± 10.7 years, and the mean BMI was 31.5 ± 7.9 kg/m^2. The majority of patients were white (66%), had an ASA class of 2 (67.4%), and had no major medical comorbidities (68.0%). On univariate analysis, patients who experienced a delayed identification of a LUT injury differed by self-reported race (P = .001) as well as history of prior abdominal surgery (P = .05).

Table 2 displays the operative characteristics of the hysterectomies performed during the study period. The most commonly performed primary surgery was laparoscopic hysterectomy, followed by abdominal hysterectomy, vaginal hysterectomy, and laparoscopic-assisted vaginal hysterectomy. Supplemental Table 1 (Appendix) provides more detailed information regarding the surgeries performed. No difference was found in terms of LUT complication across types of hysterectomy (P = .72). Cystoscopy performed at the time of hysterectomy as well as urogynecologic procedures performed at the time of hysterectomy were not significantly associated with identification of a delayed LUT injury (P = .86 and P = .89, respectively). Table 3 describes the 25 most common indications for hysterectomy, with the most common being "Null" (21,699, 48.1%), followed by "Leiomyoma of uterus, unspecified" (5877, 13.0%). Supplemental Tables 2–5 (Appendix) provide information regarding the most common procedures listed for other procedure 1 and 2 and concurrent procedure 1 and 2.

Overall, the incidence of any postoperative adverse event was 4.1% (95%CI 0.07-0.13), while the rate of readmission and reoperation were 3.2% (95% confidence interval [CI], 3.0–3.3) and 1.4% (95% confidence interval, 1.3–1.5), respectively. Patients who experienced genitourinary tract complications had longer operative times (166.5 vs 127.5 minutes, P < .001) and a greater length of hospital stay (2 days vs 1 day, P < .001). They were also more likely to experience any other postoperative adverse event (17.1% vs 4.1%, P < .001) and were more likely to be readmitted (49.5% vs 3.1%, P < .001) and to undergo reoperation (54.3% vs 1.3%, P < .001). Specific postoperative complications that were associated with LUT injury were genitourinary-related complications (renal insufficiency, P < .001 and renal failure, P < .001), as well as transfusion (P = .01) and wound complications (P = .02).

In Table 4, we describe the LUT injuries identified in the immediate postoperative period. The incidence of any LUT complication after hysterectomy was 0.2% (95% CI, 0.19–0.28): 55 ureteral obstructions (0.1%, 95% CI, 0.09–0.16), 33 ureteral fistulae (0.07%, 95% CI, 0.05–0.1), and 28 bladder fistulae (0.06%, 95% CI, 0.04–0.09). Three patients had both a ureteral fistula

FIGURE
Case selection

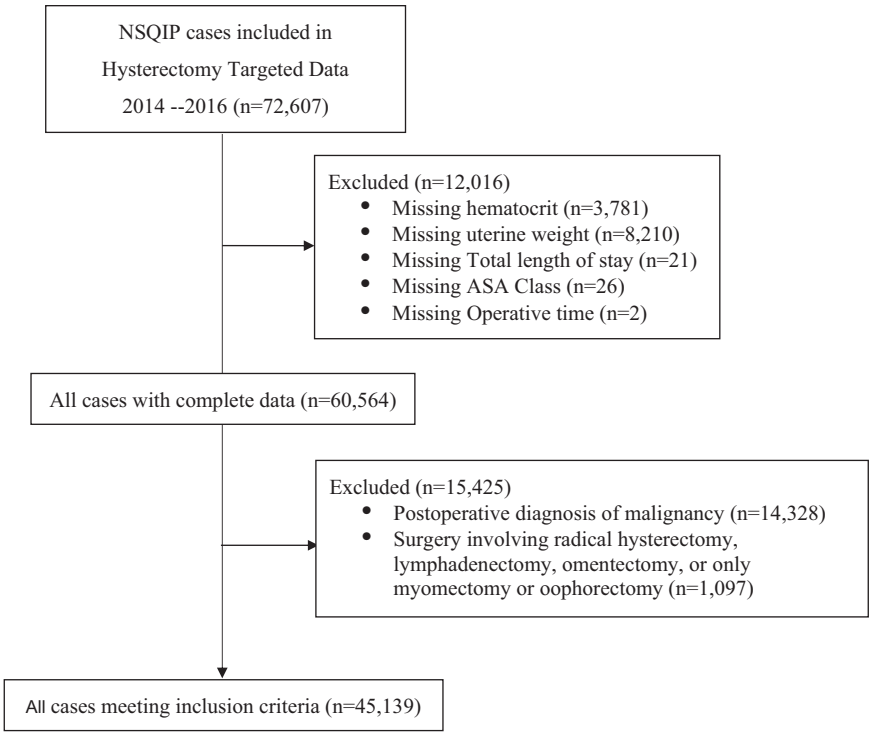

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TABLE 1
Patient characteristics

	All patients N = 45,139	Lower urinary tract complication n = 105	No lower urinary tract complication n = 45,034	*P*
Age[a] (years)	31.0 ± 10.7	30.3 ± 9.8	31.0 ± 10.7	.43
BMI[a] (kg/m^2)	31.5 ± 7.9	31.5 ± 8.6	31.4 ± 7.9	.91
Parity[b]	2 (1–3)	2 (1–3)	2 (1–3)	.34
Race[c]				.01
White	29,592 (65.6)	54 (51.4)	29,538 (65.6)	
Black	8727 (19.3)	30 (28.6)	8697 (19.3)	
Unknown	4923 (10.9)	13 (12.4)	4910 (10.9)	
Other[d]	1897 (4.2)	8 (7.6)	1889 (4.2)	
ASA class[c]				.74
1	4547 (10.1)	13 (12.4)	4534 (10.1)	
2	30,423 (67.4)	70 (66.7)	30,353 (67.4)	
3	9889 (21.9)	22 (21.0)	9867 (21.9)	
4	279 (0.6)	0	279 (0.6)	
Major medical comorbidity[c]				.89
No	30,677 (68.0)	71 (67.6)	30,606 (68.0)	
Yes	14,462 (32.0)	34 (32.4)	14,428 (32.0)	
Smoking[c]				.38
No	37,954 (84.1)	85 (81.0)	37,869 (84.1)	
Yes	7185 (15.9)	20 (19.0)	7165 (15.9)	
Prior abdominal surgery[c]				.05
No	33,020 (73.2)	68 (64.8)	32,952 (73.2)	
Yes	12,119 (26.8)	37 (35.2)	12,082 (26.8)	
Prior pelvic surgery[c]				.82
No	199,855 (44.0)	45 (42.9)	19,810 (44.0)	
Yes	25,284 (56.0)	60 (57.1)	25,224 (56.0)	

BMI, body mass index.

[a] Data are given as mean ± standard deviation; [b] Data are given as median (interquartile range); [c] Data are given as number (%); [d] "Other" includes American Indian, Alaska Native, Asian, Native Hawaiian, and Pacific Islander.

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and ureteral obstruction, 4 patients had both a ureteral fistula and bladder fistula, and 2 patients had all 3 types of genitourinary tract complications. The median number of days to identification of complications was as follows: ureteral obstruction 4.0 (1.5–11.0) days, ureteral fistula 11 (8.0–20.0) days, and bladder fistula 12.5 (4.8–22.3) days.

Table 5 describes the univariate logistic regression performed for the following variables: age, BMI, race, history of prior abdominal surgery, mode of hysterectomy, operative time, hematocrit, and diagnosis of endometriosis. Black (odds ratio [OR], 1.89; 95% CI, 1.19–2.92) and "other" race (OR, 2.32; 95% CI, 1.02–4.60), as well as history of endometriosis (OR, 2.27; 95% CI, 1.43–3.50), were found to be associated with an increased incidence LUT injury identified in the 30-day postoperative period. In a multivariable logistic regression model controlling for race, operative time, history of endometriosis, and prior abdominal surgery, black race (adjusted odds ratio [aOR], 1.90; 95% CI, 1.20–2.96), endometriosis (aOR, 2.29; 95% CI, 1.44–3.52), and prior abdominal surgery (aOR, 1.53; 95% CI, 1.01–2.28) remained significantly associated with the occurrence of any LUT complication (Table 6). Given that the majority of patients had a postoperative diagnosis that was not defined (ie, "Null"), the decision was made to exclude postoperative diagnoses as a variable in our multivariable logistic regression analysis.

Comment

This study aimed to describe the incidence of and risk factors associated with LUT complications recognized in the immediate postoperative period following hysterectomy performed for benign gynecologic indications. Using a validated national surgical database, we found that the overall incidence of genitourinary tract complications recognized within the 30-day postoperative period was 0.2%, with ureteral obstruction being the most common. Black race, diagnosis of endometriosis, and prior abdominal surgery were associated with an increased incidence of injury.

Our reported incidence of LUT injury is similar to previously reported rates of 0.03–1.5% for ureteric injury and 0.2–1.8% for bladder injury.[2] In a recent NSQIP-based study by Wallis et al[8] looking at the occurrence of LUT injury at the time of benign hysterectomy, the authors reported a rate of 1.1%; however, the objective of their study was to describe intraoperative intervention for recognized genitourinary tract injuries at the time of hysterectomy. In this study, we describe the incidence of delayed identification of an injury in the postoperative setting; however, we cannot comment on the etiology of the injury. Our data add to the literature on this topic and fill much-needed knowledge gaps related to the incidence of LUT injury at the time of hysterectomy. Still, further investigation is needed to address why such injuries

TABLE 2
Perioperative data

	All patients N = 45,139	Lower urinary tract complication n = 105	No lower urinary tract complication n = 45,034	*P*
Mode of hysterectomy[a]				.72
Abdominal hysterectomy	12,320 (27.3)	32 (30.5)	12,288 (27.3)	
Vaginal hysterectomy	7363 (16.3)	17 (16.2)	7346 (16.3)	
Laparoscopic hysterectomy	19,491 (43.2)	40 (38.1)	19,451 (43.2)	
LAVH	5965 (13.2)	16 (15.2)	5949 (13.2)	
Cystoscopy at time of surgery[a]				
No	35,960 (79.7)	86 (81.9)	35,874 (79.7)	.86
Yes	9179 (20.3)	19 (18.1)	9160 (20.3)	
Concurrent urogynecologic procedure[a]				.89
No	38,414 (85.1)	89 (84.8)	38,325 (85.1)	
Yes	6725 (14.9)	16 (15.2)	6709 (14.9)	
Specialty[a]				.55
Gynecologic oncology	7989 (17.7)	7975 (17.7)	14 (13.3)	
Maternal–fetal medicine	22 (0)	22 (0)	0	
Obstetrics–gynecology	33,015 (73.1)	32,934 (73.1)	81 (77.1)	
Reproductive endocrinology	293 (0.6)	293 (0.7)	0	
Urogynecology	3611 (0.8)	3602 (8.0)	9 (8.6)	
Other	209 (0.5)	208 (0.5)	1 (1)	
Preoperative hematocrit[b] (%)	38.7 ± 4.3	38.1 ± 4.6	38.7 ± 4.3	.16
Uterine weight[c] (grams)	142 (87.0–276)	138.0 (85.0–280.0)	142 (87.0–276)	.99
Endometriosis[a]				<.001
No	39,403 (87.3)	79 (75.2)	39,324 (87.3)	
Yes	5736 (12.7)	26 (24.8)	5710 (12.7)	
Pelvic inflammatory disease[a]				<.001
Inflammation only	638 (1.4)	3 (2.9)	635 (1.4)	
None	44,426 (98.4)	99 (94.3)	44,327 (98.4)	
Tubo-ovarian abscess	75 (0.2)	3 (2.9)	72 (0.2)	
Operative time[b] (minutes)	141.5 ± 68.6	166.5 ± 76.4	127.5 ± 68.6	.001
Total hospital stay[c] (days)	1 (1–2)	2 (1–3)	1 (1–2)	<.001
Reoperation[a]				<.001
No	44,493 (98.6)	48 (45.7)	44,445 (98.7)	
Yes	646 (1.4)	57 (54.3)	589 (1.3)	
Readmission[a]				<.001
No	42,877 (95.0)	52 (49.5)	42,825 (95.1)	
Yes	1440 (3.2)	52 (49.5)	1388 (3.1)	
Null	822 (1.8)	1 (1.0)	821 (1.8)	

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occur and how best to prevent such injuries at the time of benign hysterectomy.

We also found that ureteral obstruction was the most common LUT injury, while bladder and ureteral fistulae were rare events with an incidence of 0.06% and 0.07%, respectively. In a meta-analysis evaluating the rate of urinary

TABLE 2
Perioperative data *(continued)*

	All patients N = 45,139	Lower urinary tract complication n = 105	No lower urinary tract complication n = 45,034	*P*
Any postoperative complications	1869 (4.1)	18 (17.1)	1851 (4.1)	<.001
Renal insufficiency	22 (0.0005)	5 (4.8)	17 (0.0004)	<.001
Renal failure	15 (0.0003)	2 (1.9)	13 (0.0003)	<.001
Transfusion	1461 (3.2)	9 (8.6)	1452 (3.2)	.01
Wound complication	96 (0.2)	2 (1.9)	94 (0.2)	.02

LAVH, laparoscopically assisted vaginal hysterectomy.

[a] Data are given as number (%); [b] Data are given as mean ± standard deviation; [c] Data are given as median (interquartile range).

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TABLE 3
Postoperative diagnoses[a] (N = 45,139)

Postoperative diagnosis	N	%
Null	21,699	48.1
Leiomyoma of uterus unspecified	5877	13.0
Excessive or frequent menstruation	3047	6.8
Intramural leiomyoma of uterus	1246	2.8
Uterovaginal prolapse unspecified	1042	2.3
Endometriosis of uterus	756	1.7
Uterovaginal prolapse incomplete	648	1.4
Submucous leiomyoma of uterus	637	1.4
Other disorders of menstruation and other abnormal bleeding from female genital tract	636	1.4
Benign neoplasm of ovary	593	1.3
Dysmenorrhea	571	1.3
Unspecified symptom associated with female genital organs	567	1.3
Uterine prolapse without vaginal wall prolapse	539	1.2
Postmenopausal bleeding	452	1.0
Unspecified disorders of menstruation and other abnormal bleeding from female genital tract	423	0.9
Endometrial hyperplasia with atypia	400	0.9
Subserous leiomyoma of uterus	397	0.9
Uterovaginal prolapse complete	368	0.8
Other and unspecified ovarian cyst	329	0.7
Carcinoma in situ of cervix uteri	242	0.5
Uterine leiomyoma	238	0.5
Other specified genital prolapse	200	0.4
Unspecified genital prolapse	159	0.4
Endometriosis of pelvic peritoneum	157	0.3
Endometriosis site unspecified	143	0.3

[a] 25 most common postoperative diagnosis codes.

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tract injury during benign gynecologic surgery, the adjusted ureteric injury rate was found to be 0.3%, which is higher than our reported rate; however, these published rates also included injuries diagnosed intraoperatively, as well as those diagnosed postoperatively.[2] While the authors of this study also reported on the rate of bladder injury, they did not report on the development of genitourinary fistulae. Also, the authors did not find any evidence that intraoperative cystoscopy reduced the incidence of postoperatively detected injuries—a finding that our study also supports. When bladder injuries present in the postoperative period, genitourinary fistulae are often the most common ways in which patients present.[13] Our genitourinary fistula rates are higher than the rates reported in a recently published systematic review on urologic injuries in gynecologic laparoscopy, which reported an incidence of 0.02% for both bladder and ureteral fistulae.[4] This systematic review included many retrospective descriptive studies, which likely led to underreporting of the true incidence of genitourinary fistulae in the studied cohorts, which explains why this review reported a lower incidence of fistulae than we found using this large national database.

Unrecognized urologic injuries at the time of surgery pose significant risks for patients. In our study, patients with delayed recognition of LUT complications had significantly higher rates of readmission and reoperation and were more likely to experience other

TABLE 4
Complications

Complications	N (% {95% CI})	Number of days since index surgery[a]
Lower urinary tract injury (any)	105 (0.23 {0.19, 0.28})	
Ureteral obstruction	55 (0.13 {0.09, 0.16})	4.0 (1.5–11.0)
Ureteral fistula	33 (0.07 {0.05, 0.10})	11.0 (8.0–20.0)
Bladder fistula	28 (0.06 {.04, .09})	12.5 (4.8–22.3)

CI, confidence interval.

[a] Median (interquartile range).

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postoperative adverse events. In a very large population-based analysis by Blackwell et al[3] looking at intra- and postoperative diagnosis of ureteral injury, the rate of ureteral injury in this study was 0.8%, with a reported rate of unrecognized ureteral injury of 0.5%. Delayed recognition of injury was found to be associated with increased readmission rates, sepsis, and acute renal failure, as well as nephrostomy tube placement and development of genitourinary fistulae.[3] These factors underscore the importance of intraoperative identification and timely management of urologic injuries in order to avoid the potential consequences of delayed or unrecognized injury.

Patient-specific factors such as a history of pelvic radiation, endometriosis, uterine fibroids, and prior pelvic surgery have been cited as risk factors for urinary tract injuries at the time of gynecologic surgery.[2,5,14] In this study, we found that a history of endometriosis, prior abdominal surgery, and black race remained associated with an increased incidence of LUT complications even when controlling for other factors associated with injury. Wallis et al[8] also found an association between urinary tract injury and race, and they attributed this increased risk to a greater incidence of large uteri and uterine fibroids among black women undergoing hysterectomy. We also found that endometriosis was associated with a higher incidence of delayed identification of a LUT injury. In a large study including over 1000 patients who underwent supracervical hysterectomy for benign gynecologic disease, 14% of all the women with endometriosis experienced a ureteral injury.[15] Depending on the disease severity and location of endometriotic lesions, endometriosis can significantly alter and obscure tissue planes, placing patients at higher risk for LUT injury. Similarly, prior abdominal surgery can lead to adhesive disease and can distort important anatomy, thus increasing the risk for LUT injury. Though other studies have found an association between mode of hysterectomy and genitourinary tract complications,[2,4] we did not detect this in our study.

TABLE 5
Univariable logistic regression

Variable	Odds ratio	95% confidence interval
Age (years)	0.99	0.97–1.01
BMI (kg/m^2)	0.99	0.97–1.02
Race		
White	Referent	–
Black	1.89	1.19–2.92
Unknown	1.45	0.76–2.57
Other[a]	2.32	1.02–4.60
Mode of hysterectomy		
Abdominal hysterectomy	Referent	–
Vaginal hysterectomy	0.89	0.48–1.58
Laparoscopic hysterectomy	0.79	0.50–1.27
LAVH	1.03	0.55–1.85
Operative time (minutes)	1.00	1.00–1.01
Hematocrit (%)	0.97	0.93–1.01
Endometriosis	2.27	1.43–3.50
Prior abdominal surgery	1.48	0.98–2.20

BMI, body mass index; *LAVH*, laparoscopically assisted vaginal hysterectomy.

[a] "Other" includes American Indian, Alaska Native, Asian, Native Hawaiian, and Pacific Islander.

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Our study is one of the first to describe the incidence of and factors associated with postoperative recognition of LUT injuries specifically in the setting of hysterectomy for benign indications. Strengths of this study include its use of a well-described and validated surgical database that adheres to rigorous data collection standards. Also, this study is one of the first to describe LUT injuries that were recognized in the immediate postoperative period following hysterectomy for benign indications.

Limitations of this study are related to its retrospective design. Studies that are based on retrospective databases are subject to information and data collection biases that include inaccurate coding of procedures, diagnoses, and perioperative outcomes as well as bias from nonresponse or missing data. Additionally, because data collection is limited to 30 days after the primary surgery, we are not able to determine

TABLE 6
Multivariable logistic regression

Variable	Adjusted odds ratio	95% confidence interval
Race		
White	Referent	–
Black	1.90	1.20–2.96
Unknown	1.51	0.79–2.67
Other[a]	2.23	0.98–2.67
Operative time (minutes)	1.00	1.00–1.01
Endometriosis	2.29	1.44–3.52
Prior abdominal surgery	1.53	1.01–2.28

[a] "Other" includes American Indian, Alaska Native, Asian, Native Hawaiian, and Pacific Islander.

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whether patients manifested LUT complications, in particular fistulae, beyond this timeframe. Furthermore, patients presenting with complications to hospitals outside the NSQIP system are not captured; this may result in underreporting of complications. Also, the generalizability of the findings of studies based on the NSQIP database may be limited owing to the fact only 714 hospitals participate in NSQIP; thus the data do not represent a nationally representative sample. Even though the most common indication for hysterectomy in our study was "Null," we systematically excluded patients undergoing surgery for cancer and a priori decided patients with a "Null" postoperative diagnosis underwent surgery for benign indications. The complexity of the fistulae or sequelae related to obstruction is not clearly classified in the data. Lastly, owing to the limitations of CPT codes, we were unable to discern between laparoscopic and robotically assisted laparoscopic hysterectomy cases.

The overall incidence of LUT injury at the time of hysterectomy performed for benign indications is low. Our study found that black race, history of abdominal surgery, and a diagnosis of endometriosis are associated with LUT complications in the immediate postoperative period following hysterectomy for benign indications. Delayed recognition of bladder or ureteral injury significantly increases patient morbidity, and a high index of suspicion must always be maintained. Surgeons should counsel patients with a known or suspected diagnosis of endometriosis of their elevated risk of experiencing a LUT injury. ■

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Appendix

SUPPLEMENTAL TABLE 1
Principal procedure[a]

	Principal procedure	N	%
1	LAPS TOTAL HYSTERECT 250 GM/< W/RMVL TUBE/OVARY	12,892	28.6
2	TOTAL ABDOMINAL HYSTERECT W/WO RMVL TUBE OVARY	10,216	22.6
3	LAPS W/VAG HYSTERECT 250 GM/&RMVL TUBE&/OVARIES	3842	8.5
4	VAGINAL HYSTERECTOMY UTERUS 250 GM/<	3422	7.6
5	LAPAROSCOPY TOT HYSTERECTOMY >250 G W/TUBE/OVAR	2846	6.3
6	VAG HYST 250 GM/< W/RMVL TUBE&/OVARY	2636	5.8
7	SUPRACERVICAL ABDL HYSTER W/WO RMVL TUBE OVARY	2017	4.5
8	LAPS SUPRACRV HYSTERECT 250 GM/< RMVL TUBE/OVAR	1639	3.6
9	LAPS VAGINAL HYSTERECTOMY UTERUS 250 GM/<	899	2.0
10	LAPAROSCOPY W TOTAL HYSTERECTOMY UTERUS 250 GM/>	866	1.9
11	LAPS VAGINAL HYSTERECT > 250 GM RMVL TUBE&/OVAR	642	1.4
12	VAG HYST 250 GM/< W/RMVL TUBE OVARY W/RPR NTRCL	449	1.0
13	LAPS SUPRACRV HYSTEREC >250 G RMVL TUBE/OVARY	435	1.0
14	LAPAROSCOPY W TOTAL HYSTERECTOMY UTERUS 250 GM/<	423	0.9
15	LAPAROSCOPY SUPRACERVICAL HYSTERECTOMY 250 GM/<	395	0.9
16	LAPAROSCOPY TOTAL HYSTERECTOMY UTERUS >250 GM	323	0.7
17	VAGINAL HYSTERECTOMY 250 GM/< W/RPR ENTEROCELE	283	0.6
18	VAG HYST > 250 GM RMVL TUBE&/OVARY	192	0.4
19	LAPS W/VAGINAL HYSTERECTOMY > 250 GRAMS	179	0.4
20	VAGINAL HYSTERECTOMY UTERUS > 250 GM	172	0.4
21	LAPS SUPRACERVICAL HYSTERECTOMY >250	97	0.2
22	TOT ABD HYST W/WO RMVL TUBE OVARY W/COLPURETHRXY	67	0.1
23	VAGINAL HYSTERECTOMY W/TOT/PRTL VAGINECTOMY	65	0.1
24	VAG HYST 250 GM/< W/COLPO-URTCSTOPEXY	54	0.1
25	VAG HYSTER W/TOT/PRTL VAGINECT W/RPR ENTEROCELE	46	0.1

[a] 25 most common CPT codes.

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SUPPLEMENTAL TABLE 2
Other procedure 1[a]

	Procedure	N	%
1	NULL	26,528	58.8
2	CYSTOURETHROSCOPY	5794	12.8
3	SLING OPERATION STRESS INCONTINENCE	1065	2.4
4	COMBINED ANTEROPOSTERIOR COLPORRHAPHY	929	2.1
5	LAPAROSCOPY COLPOPEXY SUSPENSION VAGINAL APEX	919	2.0
6	COLPOPEXY VAGINAL INTRAPERITONEAL APPROACH	790	1.8
7	LAPS FULG/EXC OVARY VISCERA/PERITONEAL SURFACE	559	1.2
8	EXPLORATORY LAPAROTOMY CELIOTOMY W/WO BIOPSY SPX	505	1.1
9	ANT COLPORRHAPHY CYSTOCELE W/WO RPR URETHROCELE	479	1.1
10	OFFICE CONSULTATION NEW/ESTAB PATIENT 30 MIN	461	1.0
11	LAPAROSCOPY ENTEROLYSIS SEPARATE PROCEDURE	420	0.9
12	ENTEROLSS FRING INTSTINAL ADHESION SPX	406	0.9
13	POST COLPORRHAPHY RECTOCELE W/WO PERINEORRHAPHY	371	0.8
14	UNLISTED LAPAROSCOPIC PX ABD PERTONEUM & OMENTUM	316	0.7
15	SALPINGECTOMY COMPLETE/PARTIAL UNI/BI SPX	287	0.6
16	CMBND ANTEROPOST COLPORRHAPHY W/ENTEROCELE RPR	271	0.6
17	LAPAROSCOPY W/LYSIS OF ADHESIONS	270	0.6
18	COLPOPEXY VAGINAL EXTRAPERITONEAL APPROACH	254	0.6
19	LAPAROSCOPY W/RMVL ADNEXAL STRUCTURES	233	0.5
20	PELVIC EXAMINATION W/ANESTHESIA OTHER THAN LOCAL	198	0.4
21	LYSIS OF ADHESIONS SALPINX/OVARY	178	0.4
22	LAPS ABD PRTM&OMENTUM DX W/WO SPEC BR/WA SPX	167	0.4
23	SALPINGO-OOPHORECTOMY COMPL/PRTL UNI/BI SPX	164	0.4
24	COLPOPEXY ABDOMINAL APPROACH	163	0.4
25	URETEROLYSIS W/WORPSG URETER RETROPERIT FIBROSIS	159	0.4

[a] 25 most common CPT codes.

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SUPPLEMENTAL TABLE 3
Other procedure 2[a]

	Procedure	N	%
1	NULL	37,235	82.5
2	CYSTOURETHROSCOPY	1736	3.8
3	SLING OPERATION STRESS INCONTINENCE	831	1.8
4	COLPOPEXY VAGINAL INTRAPERITONEAL APPROACH	458	1.0
5	POST COLPORRHAPHY RECTOCELE W/WO PERINEORRHAPHY	418	0.9
6	COMBINED ANTEROPOSTERIOR COLPORRHAPHY	312	0.7
7	LAPAROSCOPY COLPOPEXY SUSPENSION VAGINAL APEX	255	0.6
8	ANT COLPORRHAPHY CYSTOCELE W/WO RPR URETHROCELE	251	0.6
9	COLPOPEXY VAGINAL EXTRAPERITONEAL APPROACH	241	0.5
10	LAPAROSCOPY ENTEROLYSIS SEPARATE PROCEDURE	240	0.5
11	ENTEROLSS FRING INTSTINAL ADHESION SPX	181	0.4
12	UNLISTED LAPAROSCOPIC PX ABD PERTONEUM & OMENTUM	151	0.3
13	PELVIC EXAMINATION W/ANESTHESIA OTHER THAN LOCAL	140	0.3
14	LAPAROSCOPY W/LYSIS OF ADHESIONS	135	0.3
15	EXPLORATORY LAPAROTOMY CELIOTOMY W/WO BIOPSY SPX	118	0.3
16	CMBND ANTEROPOST COLPORRHAPHY W/ENTEROCELE RPR	113	0.3
17	LAPS FULG/EXC OVARY VISCERA/PERITONEAL SURFACE	109	0.2
18	LYSIS OF ADHESIONS SALPINX/OVARY	102	0.2
19	UNLISTED LAPAROSCOPY PROCEDURE URETER	97	0.2
20	URETEROLYSIS W/WORPSG URETER RETROPERIT FIBROSIS	97	0.2
21	LAPS ABD PRTM&OMENTUM DX W/WO SPEC BR/WA SPX	96	0.2
22	OFFICE CONSULTATION NEW/ESTAB PATIENT 30 MIN	96	0.2
23	INSJ MESH/PROSTH PELVIC FLOOR DEFECT EACH SITE	93	0.2
24	SALPINGECTOMY COMPLETE/PARTIAL UNI/BI SPX	77	0.2
25	LAPAROSCOPY W/RMVL ADNEXAL STRUCTURES	62	0.1

[a] 25 most common CPT codes.

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SUPPLEMENTAL TABLE 4
Concurrent procedure 1[a]

	Procedure	N	%
1	NULL	42,316	93.7
2	TAP BLOCK BILATERAL BY INJECTION(S)	323	0.7
3	SLING OPERATION STRESS INCONTINENCE	218	0.5
4	CYSTOURETHROSCOPY	194	0.4
5	CYSTO W/INSERT URETERAL STENT	136	0.3
6	INJECTION ANES OTHER PERIPHERAL NERVE/BRANCH	107	0.2
7	CYSTO BLADDER W/URETERAL CATHETERIZATION	106	0.2
8	ENTEROLSS FRING INTSTINAL ADHESION SPX	105	0.2
9	LAPAROSCOPY COLPOPEXY SUSPENSION VAGINAL APEX	101	0.2
10	CYSTORRHAPHY SUTR BLDR WND INJ/RPT SIMPLE	67	0.1
11	EXCISION SKIN ABD INFRAUMBILICAL PANNICULECTOMY	61	0.1
12	LAPAROSCOPY SURG CHOLECYSTECTOMY	47	0.1
13	REPAIR FIRST ABDOMINAL WALL HERNIA	46	0.1
14	LAPAROSCOPY ENTEROLYSIS SEPARATE PROCEDURE	44	0.1
15	RPR UMBILICAL HRNA 5 YRS/> REDUCIBLE	43	0.1
16	ANT COLPORRHAPHY CYSTOCELE W/WO RPR URETHROCELE	35	0.1
17	ENTRC RESCJ SMALL INTESTINE 1 RESCJ & ANAST	35	0.1
18	URETEROLYSIS W/WORPSG URETER RETROPERIT FIBROSIS	35	0.1
19	EXCISION EXCESSIVE SKIN & SUBQ TISSUE ABDOMEN	34	0.1
20	EXPLORATORY LAPAROTOMY CELIOTOMY W/WO BIOPSY SPX	33	0.1
21	LAPAROSCOPIC APPENDECTOMY	33	0.1
22	SUTR LG INTESTINE 1/MULT PERFORAT W/O COLOSTOMY	30	0.1
23	COLPOPEXY VAGINAL INTRAPERITONEAL APPROACH	27	0.1
24	COLPOPEXY ABDOMINAL APPROACH	25	0.1
25	COMBINED ANTEROPOSTERIOR COLPORRHAPHY	23	0.1

[a] 25 most common CPT codes.

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SUPPLEMENTAL TABLE 5
Concurrent procedure 2[a]

	Procedure	N	%
1	NULL	44,188	97.9
2	CYSTOURETHROSCOPY	143	0.3
3	SLING OPERATION STRESS INCONTINENCE	58	0.1
4	CYSTO W/INSERT URETERAL STENT	41	0.09
5	INJECTION ANES OTHER PERIPHERAL NERVE/BRANCH	37	0.08
6	CYSTO BLADDER W/URETERAL CATHETERIZATION	32	0.07
7	ENTEROLSS FRING INTSTINAL ADHESION SPX	29	0.06
8	ANT COLPORRHAPHY CYSTOCELE W/WO RPR URETHROCELE	28	0.06
9	LAPAROSCOPY COLPOPEXY SUSPENSION VAGINAL APEX	26	0.06
10	POST COLPORRHAPHY RECTOCELE W/WO PERINEORRHAPHY	25	0.06
11	EXCISION EXCESSIVE SKIN & SUBQ TISSUE ABDOMEN	23	0.05
12	IMPLANT MESH OPN HERNIA RPR/DEBRIDEMENT CLOSURE	23	0.05
13	CYSTORRHAPHY SUTR BLDR WND INJ/RPT SIMPLE	18	0.04
14	COLPOPEXY VAGINAL INTRAPERITONEAL APPROACH	15	0.03
15	TAP BLOCK BILATERAL BY INJECTION(S)	14	0.03
16	URETEROLYSIS W/WORPSG URETER RETROPERIT FIBROSIS	14	0.03
17	EXPLORATORY LAPAROTOMY CELIOTOMY W/WO BIOPSY SPX	13	0.03
18	COLPOPEXY VAGINAL EXTRAPERITONEAL APPROACH	12	0.03
19	PROCTOSGMDSC RGD DX W/WO COLLJ SPEC BR/WA SPX	12	0.03
20	COMBINED ANTEROPOSTERIOR COLPORRHAPHY	11	0.02
21	LAPAROSCOPY ENTEROLYSIS SEPARATE PROCEDURE	11	0.02
22	INSJ MESH/PROSTH PELVIC FLOOR DEFECT EACH SITE	10	0.02
23	LAPAROSCOPY SLING OPERATION STRESS INCONT	8	0.02
24	RPR UMBILICAL HRNA 5 YRS/> REDUCIBLE	8	0.02
25	SUTR LG INTESTINE 1/MULT PERFORAT W/O COLOSTOMY	8	0.02

[a] 25 most common CPT codes.

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