Surgical site infection after hysterectomy

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OBJECTIVE: Our objective was to estimate the occurrence of surgical site infections (SSI) after hysterectomy and the associated risk factors.

STUDY DESIGN: We conducted a cross-sectional analysis of the 2005-2009 American College of Surgeons National Surgical Quality Improvement Program participant use data files to analyze hysterectomies. Different routes of hysterectomy were compared. The primary outcome was to identify the occurrence of 30-day superficial SSI (cellulitis) after hysterectomy. Secondary outcomes were the occurrence of deep and organ-space SSI after hysterectomy. Logistic regression models were conducted to further explore the associations of risks factors with SSI after hysterectomy.

RESULTS: A total of 13,822 women were included in our final analysis. The occurrence of postoperative cellulitis after hysterectomy was 1.6% (n = 221 women). Risk factors that were associated with cellulitis were route of hysterectomy with an adjusted odds ratio (AOR) of 3.74 (95% confidence interval [CI], 2.26–6.22) for laparotomy compared with the vaginal approach, operative time >75th percentile (AOR, 1.84; 95% CI, 1.40–2.44), American Society of Anesthesia class ≥ 3 (AOR, 1.79; 95% CI, 1.31–2.43), body mass index ≥40 kg/m^2 (AOR, 2.65; 95% CI, 1.85–3.80), and diabetes mellitus (AOR, 1.54; 95% CI, 1.06–2.24) The occurrence of deep and organ-space SSI was 1.1% (n = 154 women) after hysterectomy.

CONCLUSION: Our finding of the decreased occurrence of superficial SSI after the vaginal approach for hysterectomy reaffirms the role for vaginal hysterectomy as the route of choice for hysterectomy.

Key words: hysterectomy, outcome, postoperative complication, surgical site infection

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Recently, United States healthcare initiatives sponsored by the Centers for Medicare and Medicaid Services (CMS) and the Joint Commission on the Accreditation of Healthcare Organizations have targeted preventable hospital-acquired infections, such as postoperative surgical site infections (SSI), as a priority in improving patient safety. Effective January 2012, CMS required all Medicare-certified hospitals to publically report clinical data and outcome measures in a "Systematic Clinical Database Registry for General Surgery" in the Hospital Inpatient Quality Reporting Program.[1] The consequence for an institution or hospital not reporting will be a payment penalty as of October 2013. The 2 surgical procedures that were identified by CMS in this recent mandate for public reporting of postoperative SSI are colon surgery and hysterectomy.

Over the last 2 decades, remarkable advancements have been made in the choice of hysterectomy routes. Although the occurrence and risk factors of SSI after total abdominal hysterectomy (TAH) has been reported,[2] neither the occurrence nor the risk factors of post-hysterectomy SSI have been reported by hysterectomy route.[2-4] Better understanding of risk factors for SSI after hysterectomy can help target efforts at the reduction of modifiable risks to prevent infections. Additionally, understanding risk factors for SSI after hysterectomy can lead to better risk stratification in the reporting of quality outcomes. Our objective was to estimate the occurrence of 30-day postoperative SSI after all routes of hysterectomy and to identify associated risk factors.

Materials and Methods

We conducted a secondary database analysis of the 2005-2009 American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP) participant-use data files to analyze the data of women who underwent hysterectomies performed by gynecologic services. The ACS NSQIP is a national program for surgical quality improvement that collects uniform data on patients who undergo surgical procedures. Hospital participation in the ACS NSQIP program is voluntary and confidential. This information is collected by a formal chart review process

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TABLE 1
Demographic and clinical characteristics of 30-day postoperative superficial surgical site infection after hysterectomy (n = 13,822 women)

Variable	Cellulitis (n = 221)	No cellulitis (n = 13,601)	*P* value
Age, n (%)			1.0
<80 y	218 (98.6)	13,378 (98.4)	
≥80 y	3 (1.4)	223 (1.6)	
Race: white, n (%)	129 (58.4)	8265 (60.8)	.49
Ethnicity: Hispanic, n (%)	27 (12.2)	2180 (16.0)	.14
Diabetes mellitus, n (%)	41 (18.6)	982 (7.2%)	< .001
History of cerebrovascular accident with neurologic deficit, n (%)	1 (0.5)	65 (0.5%)	1.0
Current smoker, n (%)	51 (23.1)	2671 (19.6%)	.20
Body mass index, n (%)			< .001
<30 kg/m^2	78 (35.3)	7598 (55.9)	
≥30 and <40 kg/m^2	74 (33.5)	4564 (33.6)	
≥40 kg/m^2	69 (31.2)	1439 (10.6)	
Ascites, n (%)	6 (2.7)	104 (0.8)	< .01
Unintentional weight loss, n (%)[a]	4 (1.8)	62 (0.5)	.02
Functional status: dependent for activities of daily living, n (%)	2 (0.9)	97 (0.7)	.67
Hysterectomy for gynecologic cancer, n (%)	32 (14.5)	871 (6.4)	< .001
Preoperative anemia: hematocrit (<36%), n (%)	48 (22.3)	2976 (22.8)	.94
Preoperative creatinine level >1.5 mg/dL, n (%)	3 (1.8)	75 (0.9)	.18
American Society of Anesthesiologists class ≥3, n (%)	93 (42.1)	2521 (18.5)	< .001
Intraoperative blood transfusion, n (%)	15 (6.8)	329 (2.4)	< .001
Work relative value unit[b]	18.7 ± 5.1	17.3 ± 3.8	< .001
Operative time >75th percentile duration, n (%)	93 (42.1)	3378 (24.8)	< .001
Type of anesthesia: general, n (%)	221 (100.0)	13,111 (96.4)	.001
Wound class, n (%)			.06
1-Clean	0	33 (0.2)	
2-Clean/contaminated	215 (97.3)	13,443 (98.8)	
3-Contaminated	5 (2.3)	92 (0.7)	
4-Dirty	1 (0.5)	33 (0.2)	

[a] Loss of ≥10% of body weight in the previous 6 months not because of exercise or dieting; [b] Data are given as mean ± SD.

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in addition to a 30-day postoperative follow-up evaluation of patients.[5] Variables that are collected include preoperative characteristics, surgical information, and 30-day postoperative complications. The ACS NSQIP database and its quality control measures are further described on their website (http://www.acsnsqip.org). Exemption status for this study was obtained in writing from the Yale Human Investigation Committee, which serves as the Internal Review Board for Yale University.

Exclusion criteria included (1) male sex, (2) women with the diagnosis of current pregnancy, (3) surgical procedure within 30 days before hysterectomy, (4) *Current Procedural Terminology Coding System*, 4th edition (CPT-4), code inconsistent with hysterectomy, (5) CPT-4 code that indicates pelvic exenteration procedure at the time of hysterectomy, and (6) women with a diagnosis of preoperative infection that includes sepsis, systemic inflammatory response syndrome, and septic shock immediately before hysterectomy. After exclusion for these criteria, the remaining participants were women who underwent hysterectomy.

Hysterectomy route was assigned based on CPT-4 coding of the primary procedure: TAH, abdominal supracervical hysterectomy (SCH), total vaginal hysterectomy (TVH), laparoscopic-assisted vaginal hysterectomy (LAVH), total laparoscopic hysterectomy (TLH), and laparoscopic SCH (LASCH). We further examined SSI based on abdominal incisions: (1) laparotomy (TAH or SCH), (2) laparoscopic incisions (LAVH, TLH, or LASCH), or (3) TVH. Finally, we examined SSI based on vaginal cuff incisions: (1) no vaginal cuff incisions (SCH or LASCH) vs (2) vaginal cuff incisions (TAH, TVH, LAVH, and TLH).

Risk factors for SSI were explored and grouped into the following categories: demographic features, preoperative medical comorbidities, and intraoperative factors. Demographic features included age, race, and ethnicity. Women were dichotomized into the 2 age categories (<80 years old and ≥80 years old) because of a previously demonstrated nonlinear association between age and the log-odds of postoperative infection.[6] Preoperative comorbidities included medical diagnoses, obesity, hysterectomy for gynecologic cancer, preoperative functional status, unintentional weight loss, preoperative laboratory data, and American Society of Anesthesia (ASA) classification.

Medical diagnoses that were considered included diabetes mellitus, a history of cerebrovascular accidents (CVA) with neurologic deficit, ascites, preoperative corticosteroid use, and obesity. Obesity was classified based on body mass index (BMI). Women were categorized as having normal weight (BMI, <30 kg/m^2), obesity (BMI, ≥ 30 and <40 kg/m^2), and morbid obesity (BMI, ≥ 40 kg/m^2).[7] Women who had undergone hysterectomies for gynecologic cancer were identified by CPT-4 codes that were consistent with lymph node dissection or radical debulking, the diagnoses of preoperative ascites, preoperative disseminated cancer, preoperative chemotherapy, and preoperative radiation therapy. *Functional status* was defined as a woman's ability to perform activities of daily living, which included bathing, feeding, dressing, toileting, and mobility and was categorized as either independent or dependent. Unintentional weight loss was used as a marker of frailty and was defined as loss of $>10\%$ of bodyweight over the previous 6 months. Preoperative laboratory data were used to identify anemia and renal compromise. *Anemia* was defined as hematocrit of $<36\%$ based on the findings of Wu et al[8] and Heisler et al.[9] *Renal compromise* was defined as a creatinine level of >1.5 mg/dL based on the findings of Dowdy et al.[10] Intraoperative factors that were explored included the type of anesthesia, wound classification, intraoperative blood transfusion, and procedural difficulty. Concomitant procedures and procedural difficulty were accounted for by an examination of the total work relative value units and total operative time. Procedures had between 1 and 8 CPT codes. To consider the complexity of all the different possible combinations of procedures, work relative value units for all concomitant procedures were totaled. Operative time was categorized as a dichotomous variable above and below the 75th percentile, based on previous work by Culver et al,[11] who demonstrated that operative time of >75th percentile is a risk factor for SSI. For hysterectomies in the ACS NSQIP dataset, the operative time of >75th percentile was 149 minutes.

SSI categories were defined by the criteria found in the participant use data file of the ACS NSQIP.[12] These definitions were also based on criteria set by the Centers for Disease Control and Prevention (CDC).[13] The primary outcome was the occurrence of 30-day superficial SSI (cellulitis) after hysterectomy. *Cellulitis* was defined as an infection that involved only skin or subcutaneous tissue of the surgical incision. Secondary outcomes were the occurrence of deep and organ-space SSI and urinary tract infection (UTI) after hysterectomy. Deep and organ-space SSI included infections that involved deep soft tissues (fascia and muscle) at and around the surgical incision and infections in any part of the body that was opened or manipulated during the operative procedure. This includes vaginal cuff cellulitis and vaginal cuff abscess, peritonitis, and pelvic abscess. Deep and organ-space SSI were considered as 1 category, because these 2 categories were difficult to distinguish when hysterectomy is considered to be the primary procedure. Finally, we examined postoperative *UTI*, which was defined by CDC criteria for symptomatic UTI and asymptomatic bacteriuria, which take into account the recent use of indwelling catheters and the age of the patient.[13]

Descriptive statistics, Student t test, Pearson χ^2, and Fisher exact test (2-sided) were performed for bivariate analysis. Three logistic regression models were conducted to further explore the associations of risks factors for cellulitis, deep and organ-space SSI, and postoperative UTI after hysterectomy.[8,9] Variables that were associated with SSI were identified for potential inclusion in the final model based on bivariate analysis ($P < .1$). Variables were added to the model in a stepwise fashion with the use of forward selection ($P \leq .05$). Adjusted odds ratios (AORs) and 95% confidence intervals (CIs) were calculated. Statistical analysis was performed with STATA statistical software (version 11.0; Stata Corporation, College Station, TX) and SAS statistical software (version 9.2; SAS Institute Inc, Cary, NC).

Results

A total of 23,569 participants were classified as having undergone a gynecologic procedure in the 2005-2009 ACS NSQIP participant use dataset. The following exclusions were made from the final analysis: (1) male sex (n = 51), (2) women with the diagnosis of current pregnancy (n = 416), (3) surgical procedure within 30 days

TABLE 2
Logistic regression model for association of cellulitis after hysterectomy

Variable	Adjusted odds ratio	95% CI	*P* value
Route of hysterectomy			
Total vaginal hysterectomy (referent)	1	—	—
Laparotomy[a]	3.74	2.26–6.22	$<.001$
Laparoscopic incisions[b]	1.45	0.83–2.56	.20
Operative time >75th percentile duration	1.84	1.40–2.44	$<.001$
American Society of Anesthesiologists class ≥ 3	1.79	1.31–2.43	$<.001$
Body mass index, kg/m^2			
<30 (referent)	1	—	—
≥ 30 and <40	1.31	0.94–1.81	.11
≥ 40	2.65	1.85–3.80	$<.001$
Diabetes mellitus	1.54	1.06–2.24	.02

[a] Laparotomy included total abdominal hysterectomy and supracervical hysterectomy; [b] Laparoscopic incisions included laparoscopic-assisted vaginal hysterectomy, total laparoscopic hysterectomy, and laparoscopic supracervical hysterectomy.

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TABLE 3
Demographic and clinical characteristics of 30-day postoperative deep or organ-space surgical site infection after hysterectomy (n = 13,822)

Variable	Surgical site infection: Deep/organ-space (n = 154)	Surgical site infection: No deep/organ-space (n = 13,668)	*P* value
Age, n (%)			1.0
<80 y	152 (98.7)	13,444 (98.4)	
≥80 y	2 (1.3)	224 (1.6)	
Race: white, n (%)	73 (47.4)	8321 (60.9)	.001
Ethnicity: Hispanic, n (%)	32 (20.8)	2175 (15.9)	.12
Diabetes mellitus, n (%)	23 (14.9)	1000 (7.3)	< .01
History of cerebrovascular accident with neurologic deficit, n (%)	4 (2.6)	62 (0.5)	< .01
Current smoker, n (%)	47 (30.5)	2675 (19.6)	.001
Body mass index, n (%)			< .001
<30 kg/m^2	68 (44.2)	7608 (55.7)	
≥30 and <40 kg/m^2	50 (32.5)	4588 (33.6)	
≥40 kg/m^2	36 (23.4)	1472 (10.8)	
Ascites, n (%)	4 (2.6)	106 (0.8)	.04
Unintentional weight loss, n (%)[a]	2 (1.3)	64 (0.5)	.17
Functional status: dependent for activities of daily living, n (%)	2 (1.3)	97 (0.7)	.30
Hysterectomy for gynecologic cancer, n (%)	13 (8.4)	890 (6.5)	.32
Preoperative anemia: hematocrit (<36%), n (%)	50 (33.8)	2974 (22.7)	< .01
Preoperative creatinine >1.5 mg/dL, n (%)	3 (2.8)	75 (0.9)	.08
American Society of Anesthesiologists class ≥3, n (%)	54 (35.1)	2560 (18.7)	< .001
Intraoperative blood transfusion, n (%)	8 (5.2)	336 (2.5)	.06
Work relative value unit[b]	17.8 ± 4.6	17.3 ± 3.8	.13
Operative time: >75th percentile duration, n (%)	51 (33.1)	3420 (25.0)	.03
Type of anesthesia: general, n (%)	148 (96.1)	13,184 (96.5)	.82
Wound class, n (%)			.16
1-Clean	0	33 (0.2)	
2-Clean/contaminated	150 (97.4)	13,508 (98.8)	
3-Contaminated	3 (2.0)	94 (0.7)	
4-Dirty	1 (0.7)	33 (0.2)	

[a] Loss of ≥10% of body weight in the previous 6 months not because of exercise or dieting; [b] Data are given as mean ± SD.

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before hysterectomy (n = 185), (4) CPT-4 code inconsistent with hysterectomy (n = 8943), (5) CPT-4 code that indicated pelvic exenteration procedure at the time of hysterectomy (n = 10), and (6) women with diagnosis of preoperative infection that included sepsis, systemic inflammatory response syndrome, and septic shock immediately before hysterectomy (n = 142). A total of 13,822 women underwent hysterectomy and were included in our final analysis.

Cellulitis

The overall occurrence of cellulitis (superficial SSI) after hysterectomy was 1.6% (n/N = 221/13,822). Four women (0.03%) received a diagnosis of both postoperative cellulitis and deep or organ-space SSI. Twelve women (0.08%) received a diagnosis of both postoperative cellulitis and UTI. Variables that were associated with cellulitis on bivariate analysis included diabetes mellitus ($P < .001$), BMI category ($P < .001$), preoperative ascites ($P < .01$), unintentional weight loss ($P = .02$),

hysterectomy for cancer ($P < .001$), ASA class ≥3 ($P < .001$), work relative value unit ($P < .001$), use of general anesthesia ($P = .001$), and an operative time >75th percentile ($P < .001$; Table 1).

Variables that were associated with 30-day postoperative cellulitis on multivariate logistic regression were the route of hysterectomy with an AOR of 3.74 (95% CI, 2.26–6.22) for laparotomy incisions compared with vaginal approach, operative time >75th percentile (AOR, 1.84; 95% CI, 1.40–2.44), ASA class ≥3 (AOR, 1.79; 95% CI, 1.31–2.43), morbid obesity (BMI, ≥40 kg/m^2; AOR, 2.65; 95% CI, 1.85–3.80), and diabetes mellitus (AOR, 1.54; 95% CI, 1.06–2.24; Table 2).

Deep and organ-space SSI

The occurrence of deep and organ-space SSI was 1.1% (n/N = 154/13,822) after hysterectomy. No women were categorized as having both a deep space SSI and an organ-space SSI. Twenty-one women (0.1%) were diagnosed with both postoperative deep/organ-space SSI and UTI. Variables that were associated with deep and organ-space SSI on bivariate analysis included race ($P = .001$), diabetes mellitus ($P < .01$), history of CVA with neurologic deficit ($P < .01$), current smoking ($P = .001$), obesity category ($P = .11$), preoperative ascites ($P = .04$), preoperative anemia ($P < .01$), ASA class ≥3 ($P < .001$), and an operative time >75th percentile ($P = .03$; Table 3).

Variables that were associated with deep and organ-space SSI on multivariate logistic regression included ASA class ≥3 (AOR, 1.81; 95% CI, 1.25–2.62), current smoking (AOR, 1.99; 95% CI, 1.40–2.83), history of CVA with neurologic deficit (AOR, 4.41; 95% CI, 1.54–12.65), preoperative anemia (AOR, 1.72; 95% CI, 1.21–2.43), and morbid obesity (AOR, 2.23; 95% CI, 1.43–3.49; Table 4). When we examined hysterectomy route, both by abdominal incisions and by vaginal cuff incisions, with deep and organ-space SSI, we did not find any significant associations.

UTI

Postoperative UTI occurred in 2.7% of women (n/N = 370/13,822) after hysterectomy. Variables that were associated with postoperative UTI on bivariate analysis included history of CVA with neurologic deficit ($P = .01$), ASA class ≥3 ($P < .01$), and an operative time >75th percentile ($P < .001$; Table 5). Variables that were associated with postoperative UTI on multivariate logistic regression were a history of CVA with neurologic deficit (AOR, 3.29; 95% CI, 1.41–7.70), current corticosteroid use (AOR, 2.37; 95% CI, 1.14–4.90), and operative time >75th percentile (AOR, 1.86; 95% CI, 1.52–2.29; Table 6).

TABLE 4
Logistic regression model for association of deep or organ space surgical site infection after hysterectomy

Variable	Adjusted odds ratio	95% CI	*P* value
American Society of Anesthesiologists class ≥3	1.81	1.25–2.62	< .01
Current smoker	1.99	1.40–2.83	< .001
History of cerebrovascular accident with neurologic deficit	4.41	1.54–12.65	< .01
Preoperative anemia (hematocrit, <36%)	1.72	1.21–2.43	< .01
Body mass index, kg/m^2			
<30 (referent)	1	—	—
≥30 and <40	1.19	0.82–1.74	.36
≥40	2.23	1.43–3.49	< .001

CI, confidence interval.

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Occurrence of SSI by route of hysterectomy

When we examined 6 different routes of hysterectomy (TAH, SCH, TLH, LASCH, LAVH, and TVH), we noticed similarities in the occurrence of SSI by abdominal incision type (Table 7). We examined routes of hysterectomy solely based on abdominal incisions (laparotomy, laparoscopic incisions, and no abdominal incisions) and noted that the route of hysterectomy was associated with superficial SSI, but not deep/organ-space SSI or postoperative UTI. Finally, we examined the association of post-hysterectomy SSI by the presence or absence of vaginal cuff incisions (SCH vs vaginal colpotomy) and found no association with any postoperative SSI.

Comment

We found the overall occurrence of both 30-day cellulitis (superficial SSI) and deep and organ-space SSI after hysterectomy to be 2.7%. The occurrence of UTI after hysterectomy was 3.0%.

The following risk factors were associated with the occurrence of postoperative cellulitis: hysterectomy route, operative time >75th percentile (149 minutes), ASA class ≥3, diabetes mellitus, and obesity category (BMI, ≥40 kg/m^2). We did not find smoking status or hysterectomy for gynecologic cancer to be independent risk factors for postoperative cellulitis.

Our finding of the decreased occurrence of superficial SSI after the vaginal approach for hysterectomy reaffirms the long-appreciated role for vaginal hysterectomy as the route of choice for hysterectomy.[14-16] Laparotomy independently increased the risk of superficial SSI after hysterectomy. A trend was seen for increased SSI with trocar incisions (minimally invasive hysterectomies), but this was not statistically significant.

Our findings add to previous work with National Healthcare Safety Network (NHSN) data to examine SSI.[2,17] The NHSN is an internet-based surveillance system that is used by the CDC to monitor hospital-acquired infections that include SSI.[18] Originally, the NHSN-based risk

TABLE 5
Demographic and clinical characteristics of 30-day postoperative urinary tract infection after hysterectomy (n = 13,822)

Variable	Urinary tract infection (n = 402)	No urinary tract infection (n = 13,420)	*P* value
Age, n (%)			.16
<80 y	392 (97.5)	13,204 (98.4%)	
≥80 y	10 (2.5)	216 (1.6%)	
Race: white, n (%)	259 (64.4)	8135 (60.6%)	.13
Ethnicity: Hispanic, n (%)	57 (14.2)	2150 (16.0%)	.37
Diabetes mellitus, n (%)	23 (5.7)	1000 (7.5)	.21
History of cerebrovascular accident with neurologic deficit, n (%)	6 (1.5)	60 (0.5)	.01
Current smoker, n (%)	90 (22.4)	2632 (19.6)	.18
Body mass index			.42
<30 kg/m^2	215 (53.5)	7461 (55.6)	
≥30 and <40 kg/m^2	147 (36.6)	4491 (33.5)	
≥40 kg/m^2	40 (10.0)	1468 (10.9)	
Ascites, n (%)	2 (0.5)	108 (0.8)	.77
Unintentional weight loss, n (%)[a]	4 (1.0)	62 (0.5)	.13
Functional status: dependent for activities of daily living, n (%)	6 (1.5)	93 (0.7)	.07
Hysterectomy for gynecologic cancer, n (%)	26 (6.5)	877 (6.5)	1.00
Preoperative anemia: hematocrit (<36%), n (%)	79 (20.6)	2945 (22.9)	.32
Preoperative creatinine >1.5 mg/dL, n (%)	3 (1.2)	75 (0.9)	.51
American Society of Anesthesiologists class ≥3, n (%)	99 (24.6)	2515 (18.7)	< .01
Intraoperative blood transfusion, n (%)	9 (2.2)	335 (2.5)	.87
Work relative value unit[b]	17.1 ± 3.8	17.3 ± 3.8	.33
Operative time: >75th percentile duration, n (%)	153 (38.1)	3318 (24.7)	< .001
Type of anesthesia: general, n (%)	393 (97.8)	12,939 (96.4)	.17
Wound class, n (%)			.87
1-Clean	0	33 (0.3)	
2-Clean/contaminated	398 (99.0)	13,260 (98.8)	
3-Contaminated	3 (0.8)	94 (0.7)	
4-Dirty	1 (0.3)	33 (0.3)	

[a] Loss of 10% or more of body weight in the previous 6 months not because of exercise or dieting; [b] Data are given as mean ± SD.

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adjustment for all SSI was based on the predictive model of Culver et al[11] that incorporated wound classification, ASA classification, and operative time. Using these risk factors, Edwards et al[2] analyzed nearly 7000 hysterectomies that were reported to the NHSN. The occurrence of all postoperative SSI (superficial, deep and organ-space) after TVH was 0.9% and after TAH was 1.7%. Unlike the reports by Culver et al and Edwards et al, our study sought to identify risk factors for SSI that are more specific to hysterectomy. By examining various possible risk factors, our study suggests additional risk factors, such as route of hysterectomy, preoperative anemia, smoking status, and history of CVA that should be considered in future studies that examine SSI after hysterectomy.

Our findings are based on multi-institutional data that were collected in a standardized fashion. Olsen et al[3] performed a multicenter retrospective

TABLE 6
Logistic regression model for association of urinary tract infection after hysterectomy

Variable	Adjusted odds ratio	95% CI	*P* value
History of cerebrovascular accident with neurologic deficit	3.29	1.41–7.70	< .01
Current corticosteroid use	2.37	1.14–4.90	.02
Operative time >75th percentile duration	1.86	1.52–2.29	< .001

CI, confidence interval.

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case-controlled study with approximately 800 patients after TAH and TVH. The cases and control subjects were collected with the use of the International Classification of Diseases, Ninth Revision, Clinical Modification procedure codes for hysterectomy from 4 participating CDC Prevention Epicenter Program hospitals from 2003-2005. Both BMI >35 kg/m^2 and intra-/postoperative blood transfusion were identified as independent risk factors for superficial SSI after hysterectomy with laparotomy. Similarly, a single institution chart review also found obesity (BMI, ≥30 kg/m^2) and blood transfusion (pre-, intra-, and postoperative) to be associated with all SSI after abdominal hysterectomy.[4] However, others have found obesity not to be a risk factor for postoperative complications after gynecologic surgery.[19] We found that, by considering BMI >30 kg/m^2, BMI was identified as a risk-factor for superficial SSI (cellulitis).

In our larger multicenter analysis, we did not find an association between preoperative transfusion and SSI. Although intraoperative transfusion was identified in our bivariate analysis to be associated with cellulitis and deep/organ-space SSI, we did not find a statistically significant association between intraoperative transfusion and SSI after adjusting for other variables. The differences in our findings and previous reports regarding transfusion (both pre- and intraoperative) as a risk factor for SSI after hysterectomy likely are related to the robust sample size of our study.

We identified risk factors that were associated with deep and organ-space SSI after hysterectomy that included preoperative anemia and history of CVA, which may be reflective of chronic preoperative systemic disease. These risk factors are in addition to risk factors of ASA class ≥3, current smoking status, and morbid obesity (BMI, ≥40 kg/m^2). We did not find a statistically significant difference in deep and organ-space SSI between different hysterectomy routes. We hypothesize that our findings of increased association of both preoperative anemia and history of CVA with deep and organ-space SSI may reflect a decrease of the body's ability to respond to stressors of surgery and to combat postoperative infection. We found an association between preoperative CVA with residual neurologic deficit and the risk of deep and organ-space SSI. CVA has been noted to be associated significantly with any adverse postoperative event.[20] We believe that we may have observed this relationship because CVA with residual neurologic deficit is a risk factor for functional dependence.[21] Chen et al[22] found functional dependence to be an independent risk factor for postoperative SSI, specifically methicillin-resistant *Staphylococcus aureus* SSI, in older adults.

We did not find differences in risk factors for deep and organ-space SSI when we examined these infections separately. We ultimately chose to combine these 2 categories when examining SSI after hysterectomy. We believe that deep and organ-space SSI, although defined distinctly by the ACS NSQIP and CDC criteria, are functionally the same event after hysterectomy because of the incision at the vaginal cuff. After a hysterectomy, an example of a deep SSI would be considered a vaginal cuff abscess. We believe that a pelvic abscess that drains through the vaginal cuff, which would be considered as a deep space SSI draining through the surgical incision, is essentially similar to a pelvic abscess that requires drainage through interventional radiology, which alternatively would be categorized as an organ-space SSI. Because of the overlap between these terms, we elected to combine deep and organ-space SSI.

The risk factors associated with postoperative UTI after hysterectomy were a history of CVA with neurologic deficit, chronic steroid use, and operative time >75th percentile. We found the occurrence of 30-day postoperative UTI was 3.0% (n = 402 women) after hysterectomy. Unfortunately, we did not have information on catheter use or duration because of limits of the dataset.

One hundred forty-two women were identified as having preoperative systemic infection that included sepsis, septic shock, and systemic inflammatory response syndrome and were excluded because of the inherent difference in these cases from women who undergo scheduled elective surgery. Although these conditions may be associated with a greater risk of postoperative SSI, the small numbers and the various different causes of systemic infection made it difficult to draw conclusions in the current study.

Our study has many limitations. The first is that our analysis was limited to the variables that existed in the database. For example, we were limited by the ACS NSQIP definition of deep and organ-space SSI; therefore, we were also unable to distinguish between pelvic abscesses, vaginal cuff cellulitis, or fasciitis.

Second, specific variables were not collected in the general ACS-NSQIP dataset that would have enhanced our study findings. For example, the type and timing of preoperative prophylactic antibiotic administration, which is a factor linked to postoperative infection,[23,24] were not available in the database. Another limitation of this dataset was the lack of information about the

TABLE 7
All 30-day postoperative surgical site infections and urinary tract infections by hysterectomy route (n = 13,822)

Type of surgical site infection	n	Total abdominal hysterectomy, n (%)	Supracervical hysterectomy, n (%)	Total vaginal hysterectomy, n (%)	Laparoscopic-assisted vaginal hysterectomy, n (%)	Total laparoscopic hysterectomy, n (%)	Laparoscopic supracervical hysterectomy, n (%)
None	13,081 (94.6)	5069 (93.8)	688 (94.0)	2921 (95.3)	2094 (94.3)	837 (95.2)	1472 (96.7)
Cellulitis	217 (1.6)	141 (2.6)	17 (2.3)	17 (0.6)	17 (0.8)	5 (0.6)	20 (1.3)
Deep/organ-space	154 (1.1)	67 (1.2)	8 (1.1)	32 (1.0)	33 (1.5)	4 (0.5)	10 (0.7)
Urinary tract infection	370 (2.7)	128 (2.4)	19 (2.6)	94 (3.1)	76 (3.4)	33 (3.8)	20 (1.3)

Lake. Surgical site infections after hysterectomy. Am J Obstet Gynecol 2013.

indication for hysterectomy. Surgical procedures were categorized by CPT codes alone. The occurrence of postoperative UTI after prolapse or antiincontinence surgery has been reported to be higher than that found in our study.[25] Because the women were selected for inclusion in this study based on hysterectomy and not prolapse or incontinence procedures, we were not able to determine the occurrence of UTI after prolapse or incontinence procedures in our current analysis.

We did not find an association with hysterectomies that were performed for gynecologic cancer and SSI based on CPT-4 codes. This finding may also be due to the lack of specific information in the dataset regarding cancer stage, grade, and pathologic condition in the ACS NSQIP dataset. We were limited to the identification of procedures for gynecologic cancer based on CPT-4 codes that indicated radical dissection and lymphadenectomies. Additionally, some hysterectomies for cancer that required bowel resection may have been coded primarily as colon surgery and therefore not included in our analysis. We did examine all cancer variables that were available in the ACS NSQIP dataset (including known disseminated tumor, chemotherapy, or radiation therapy within 30 days before procedure and known central nervous system tumor) both individually and as a composite group and did not find a statistically significant association with SSI. This, again, likely reflects the limitation of the dataset because it does not include cancer stage, grade, and disease.

Last, hospital participation in the ACS NSQIP is voluntary and confidential, which may introduce selection bias; however, as of 2009, >320 hospitals were participating in the ACS NSQIP program, which included a wide-range of community hospitals and tertiary care centers. The ACS NSQIP participant-use data files do not allow for identification of participating hospitals within the dataset; therefore, we were not able to account for the effect of clustering of observations within centers. However, previous investigators have demonstrated that the clustering effect from the ASC NSQIP for other endpoints is minimal and did not change the overall adjusted outcomes.[5,26]

Our study suggests that numerous factors, which include hysterectomy route, operative time, diabetes mellitus, ASA class ≥3, BMI, smoking status, preoperative anemia, CVA with neurologic deficit, and corticosteroid use are associated with SSI after hysterectomy. Development of a predictive model for SSI after all types of hysterectomy is needed. Unfortunately, we cannot develop a predictive model with this current work because of a lack of a validation cohort.

Decreasing preventable hospital-acquired infections is important for the sake of quality patient care. In light of the recent national CMS mandate that requires all Medicare-certified hospitals to report data and outcome measures publicly, the prevention of SSI will soon become important for a hospital's financial stability as well.[1] The ACS NSQIP program to improve quality and patient safety has succeeded by providing timely, consistent, confidential, risk-adjusted feedback to participating institutions on the institutional occurrence of a wide range of postoperative complications.[5] Institutions immediately can identify systems and strategies to improve patient outcomes in outlying areas.[5] This confidential risk-adjusted program has begun to improve surgical outcomes. Knowledge of the baseline occurrence of postoperative SSI after different routes of hysterectomy and associated risk factors is important to improve patient safety after hysterectomy by helping to identify modifiable factors to prevent SSI. Because CMS enforces mandatory public reporting of postoperative SSI after hysterectomy without risk adjustment specific to hysterectomy, careful monitoring must be used to identify unintended consequences. ■

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