Original Investigation

Surgical Site Infections Following Ambulatory Surgery Procedures

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IMPORTANCE Surgical site infections can result in substantial morbidity following inpatient surgery. Little is known about serious infections following ambulatory surgery.

OBJECTIVE To determine the incidence of clinically significant surgical site infections (CS-SSIs) following low- to moderate-risk ambulatory surgery in patients with low risk for surgical complications.

DESIGN, SETTING, AND PARTICIPANTS Retrospective analysis of ambulatory surgical procedures complicated by CS-SSIs that require a postsurgical acute care visit (defined as subsequent hospitalization or ambulatory surgical visit for infection) using the 2010 Healthcare Cost and Utilization Project State Ambulatory Surgery and State Inpatient Databases for 8 geographically dispersed states (California, Florida, Georgia, Hawaii, Missouri, Nebraska, New York, and Tennessee) representing one-third of the US population. Index cases included 284 098 ambulatory surgical procedures (general surgery, orthopedic, neurosurgical, gynecologic, and urologic) in adult patients with low surgical risk (defined as not seen in past 30 days in acute care, length of stay less than 2 days, no other surgery on the same day, and discharged home and no infection coded on the same day).

MAIN OUTCOMES AND MEASURES Rates of 14- and 30-day postsurgical acute care visits for CS-SSIs following ambulatory surgery.

RESULTS Postsurgical acute care visits for CS-SSIs occurred in 3.09 (95% CI, 2.89-3.30) per 1000 ambulatory surgical procedures at 14 days and 4.84 (95% CI, 4.59-5.10) per 1000 at 30 days. Two-thirds (63.7%) of all visits for CS-SSI occurred within 14 days of the surgery; of those visits, 93.2% (95% CI, 91.3%-94.7%) involved treatment in the inpatient setting. All-cause inpatient or outpatient postsurgical visits, including those for CS-SSIs, following ambulatory surgery occurred in 19.99 (95% CI, 19.48-20.51) per 1000 ambulatory surgical procedures at 14 days and 33.62 (95% CI, 32.96-34.29) per 1000 at 30 days.

CONCLUSIONS AND RELEVANCE Among patients in 8 states undergoing ambulatory surgery, rates of postsurgical visits for CS-SSIs were low relative to all causes; however, they may represent a substantial number of adverse outcomes in aggregate. Thus, these serious infections merit quality improvement efforts to minimize their occurrence.

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JAMA. 2014;311(7):709-716. doi:10.1001/jama.2014.4

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Surgical site infections (SSIs) are among the most common health care-associated infections. Surgical site infections account for 20% to 31% of health care-associated infections in hospitalized patients[1,2] and have considerable morbidity, a mortality rate of 3%, stays prolonged by 7 to 10 days, and costs of $20 000 to $27 600 per admission.[2-5] Reducing SSIs is a national priority, as reflected in the US Department of Health and Human Services' National Action Plan to Prevent Healthcare-Associated Infections.[6] Initially focused on high-priority areas related to health care-associated infections within acute care hospitals, the action plan broadened to address additional types of health care settings, including ambulatory surgery.[7] Although ambulatory surgeries represent a substantial portion of surgical health care, there is a dearth of information on adverse events, including health care-associated infections following operations performed in the ambulatory setting.[8-10]

The problem of health care-associated infections following ambulatory surgery may not be small. The preponderance of surgical procedures are now performed in ambulatory settings.[11] Ambulatory surgery cases totaled 18.7 million in 2010 in the United States[12] and accounted for 63.6% of all operations.[13] During inspections of Medicare-certified ambulatory surgical centers, serious breaches of infection control practices were found to be common.[14] Yet very little information is available regarding infectious outcomes following ambulatory operations.

To better understand the spectrum of clinically significant infections that follow ambulatory surgery, we calculated population estimates of 14- and 30-day acute care visit rates (ie, hospitalizations or ambulatory surgical visits) for clinically significant SSIs (CS-SSIs) following selected low- to moderate-risk ambulatory surgical procedures performed on adults with low surgical risk.

Methods

Databases and Study Population

Encounter data were abstracted from 2010 Agency for Healthcare Research and Quality Healthcare Cost and Utilization Project (HCUP) State Ambulatory Surgery Databases and State Inpatient Databases.[15] State Ambulatory Surgery Databases include all-payer, encounter-level information on surgical procedures performed in hospital-owned ambulatory settings, with no overnight inpatient stay. These include surgical suites within the hospital as well as physically freestanding surgical facilities owned by the hospital. The data do not include procedures performed in physician offices or freestanding facilities not owned by a hospital. State Inpatient Databases contain all-payer, encounter-level information on inpatient discharges. HCUP state databases are discharge-level (not patient-level) files; each record represents 1 ambulatory surgical visit or inpatient stay. Discharge abstracts contain information found on a billing record, such as demographics; up to 30 *International Classification of Diseases, Ninth Revision, Clinical Modification* (*ICD-9-CM*) diagnoses, *ICD-9-CM* procedures or *Current Procedural Terminology* (*CPT*) procedures, or both; length of stay; expected payer; admission and discharge dates; and discharge disposition.

Although the HCUP contains data from 47 states,[16] 8 states have data from the 2 settings of interest (ambulatory surgery and inpatient) and robust encrypted identifiers that allow patients to be observed across time and across hospital settings. The present study used data from those 8 states (California, Florida, Georgia, Hawaii, Missouri, Nebraska, New York, and Tennessee), accounting for one-third of the US population.

We initially identified records for selected low- to moderate-risk surgical procedures performed in hospital-owned ambulatory surgery settings in 2010. Twelve surgical procedures were selected, including a spectrum of specialties: general surgery, orthopedics, neurosurgery, gynecology, and urology (eAppendix 1 in Supplement). Selected general surgery procedures included laparoscopic cholecystectomy and 6 types of hernia repair (open and laparoscopic for inguinal or femoral; umbilical; and incisional or abdominal). Selected orthopedic procedures and neurosurgical procedures included spinal laminectomy or diskectomy and anterior cruciate ligament (ACL) repair. Selected gynecologic procedures included vaginal and abdominal hysterectomy, excluding those performed for treatment of cancer. The selected urologic procedure was transurethral prostatectomy, excluding procedures performed for treatment of cancer. These selected surgical procedures were considered low to moderate risk, because they are moderately invasive and require general or regional anesthesia. The surgical procedures are elective, of short duration, and do not require an overnight inpatient stay.

To determine how representative the surgical procedures conducted at hospital-owned settings are for all outpatient surgical procedures, we examined the type of ambulatory setting where each procedure was performed using 2 HCUP State Ambulatory Surgery Databases states (Florida and South Carolina) with complete reporting of data in ambulatory surgery settings regardless of hospital ownership.

Our overall objective was to analyze a population of adult patients with low surgical risk. Therefore, we excluded patients who had been seen in acute care in the prior 30 days, had a length of stay of 2 or more days, experienced more than 1 surgery on the same day, or had an infection coded on the day of surgery.

Measures

Primary Outcomes

The primary outcome was the rate of postsurgical acute care visits following each of the selected surgical procedures. The denominator was the number of ambulatory surgical procedures. The numerator was the number of those procedures that resulted in at least 1 subsequent ambulatory surgery visit or inpatient stay for a CS-SSI within 14 or 30 days. A patient with a subsequent visit was counted only once in the numerator, regardless of other visits within the 14- or 30-day postsurgical period. To target the analysis to clinically important, serious infections, postsurgical visits were limited to hospitalizations (including those that began in the emergency department) and ambulatory surgical visits. Patients with SSIs who made postsurgical visits to physician

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offices or who were released from emergency departments were not included, because their infections were considered less serious. The rates were reported per 1000 ambulatory surgical procedures. The time between the index ambulatory surgical procedure and a subsequent ambulatory surgical visit or inpatient stay was calculated from the discharge date of the index ambulatory surgical procedure to the admission date of the subsequent visit.

Postsurgical encounters for CS-SSIs were identified by an algorithm that used *ICD-9-CM* diagnosis codes, *ICD-9-CM* or *CPT* procedure codes, or both on a discharge abstract for an ambulatory surgical visit or inpatient stay subsequent to the surgery. CS-SSIs included infections generally related to surgery as well as those specific to the type of surgery (eAppendix 2 in Supplement). A sensitivity analysis was conducted to determine the validity of the algorithm. The sensitivity analyses examined which types of codes identified infections using the following hierarchy: (1) any listed procedure specific to an infection from the surgery, such as arthroscopy of the knee for lavage and drainage of infection for ACL repair, (2) any listed diagnosis indicating infection specific to the surgery, such as a diagnosis of peritonitis and cellulitis of the trunk for abdominal procedures, (3) any listed procedure indicating an infection generally related to having surgery, such as drainage of an abscess or debridement of infected skin, and (4) any listed diagnosis indicating an infection, such as pyoderma, local skin infection, or postoperative infection.

We computed rates of ambulatory surgical visits or postsurgical inpatient stays for all causes (including CS-SSIs) to indicate the relative importance of SSIs as a reason for postsurgical visits. Additional reasons for postsurgical visits included, but were not limited to, postoperative pain and swelling, gastrointestinal conditions, respiratory conditions, constitution-related diagnoses (eg, dizziness, syncope, fever, dehydration), and more general infections (eg, methicillin-resistant *Staphylococcus aureus*, *Clostridium difficile*, pneumonia, urinary tract infections).

Demographic Characteristics

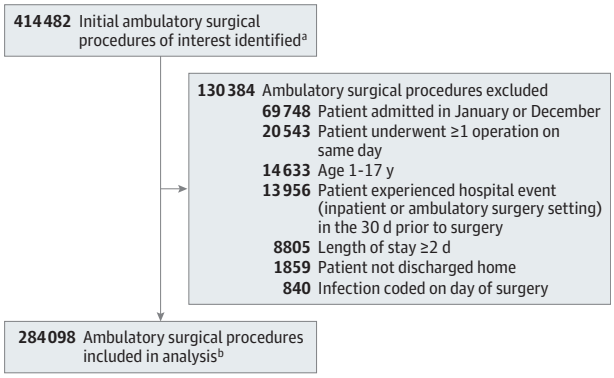
The patient's age, sex, and residential area were based on the index ambulatory surgical visit. We classified primary expected payer into 5 groups: Medicare, Medicaid, private insurance, uninsured (self-pay or no charge), and other types of insurance.

Statistical Analysis

We examined patient and payer characteristics associated with ambulatory surgical procedures. Observed rates of postsurgical acute care visits for CS-SSIs and all causes were assessed at 14 and 30 days. We determined observed rates of postsurgical visits for CS-SSIs by type of surgery. Jeffreys intervals were used to calculate 95% CIs, assuming a binomial distribution.[17] We made comparisons between rates of postsurgical visits following open and laparoscopic surgery for hernia repair and vaginal and abdominal hysterectomies.

The use of HCUP administrative data is not considered human subjects research by the Agency for Healthcare Research and Quality institutional review board. Analyses were conducted using Base SAS and SAS/STAT version 9. 3 (SAS Institute Inc). The criterion for statistical significance was a 2-sided χ^2 test at $P < .01$.

Figure. Ambulatory Surgical Procedures Meeting Study Criteria[a]



[a] Source: Agency for Healthcare Research and Quality, Center for Delivery, Organization, and Markets, Healthcare Cost and Utilization Project; State Ambulatory Surgery Databases and State Inpatient Databases for 8 states: California, Florida, Georgia, Hawaii, Missouri, Nebraska, New York, and Tennessee, 2010.

[b] Patients total 282 086; some patients underwent more than 1 ambulatory surgical procedure that met all of the study criteria.

Results

The **Figure** displays the selection of index ambulatory surgical procedures. We extracted all ambulatory surgery records for patients with any *ICD-9-CM* procedure or *CPT* codes related to 1 of the 12 surgical procedures (n = 414 482). We excluded records for surgical procedures performed in January or December to allow a window of 30 days before and after surgery to examine other hospital visits (n = 69 748). Next, we excluded ambulatory surgical procedures that signaled a complication in care because of a discharge disposition other than routine (n = 1859) or with a length of stay of 2 or more days (n = 8805).

To select a homogeneous group of patients at low surgical risk, we excluded additional patients with more than 1 of the selected surgical procedures on the same ambulatory surgery visit (n = 20 543), any ambulatory surgical visit or inpatient stay within the previous 30 days (n = 13 956), and infection on the surgery day (n = 840). Patients younger than 18 years (n = 14 633) were also excluded. We retained 284 098 records for ambulatory surgical procedures performed in a hospital-owned ambulatory setting.

eAppendix 3 in Supplement shows that for all but 1 of the ambulatory surgical procedures of interest, at least two-thirds (and 80% or greater for 9 of the 12 surgical procedures) were performed at hospital-owned settings. Patients with more than 1 ambulatory surgical procedure during the 10-month period may be represented more than once: the 284 098 ambulatory surgical procedures represented 282 086 patients.

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Table 1. Characteristics of Patients Undergoing Ambulatory Surgical Procedures in Hospital-Owned Settings, 2010[a]

Type of Surgery	Index Surgical Procedures, No.	Age, Mean (95% CI), y	No. (%)		
			Women	Metropolitan Residence	Primary Expected Payer: Private
All surgery	284 098	51.2 (51.1-51.2)	136 710 (48.1)	238 885 (84.1)	166 385 (58.6)
General surgery					
Laparoscopic cholecystectomy	92 195	47.7 (47.6-47.8)	69 935 (75.9)	75 692 (82.1)	56 854 (61.7)
Hernia repair					
Open inguinal or femoral	56 678	58.2 (58.1-58.4)	5938 (10.5)	49 615 (87.5)	26 136 (46.1)
Laparoscopic inguinal or femoral	14 651	54.4 (54.2-54.7)	900 (6.1)	13 207 (90.1)	8840 (60.3)
Open umbilical	20 231	49.4 (49.2-49.6)	6276 (31.0)	17 643 (87.2)	12 819 (63.4)
Laparoscopic umbilical	4528	51.0 (50.6-51.4)	1959 (43.3)	3953 (87.3)	2787 (61.6)
Open incisional or abdominal	15 819	54.0 (53.8-54.2)	8925 (56.4)	13 480 (85.2)	8299 (52.5)
Laparoscopic incisional or abdominal	2969	55.5 (55.0-56.0)	1757 (59.2)	2584 (87.0)	1563 (52.6)
Orthopedic or neurosurgical					
Spine surgery	24 929	50.9 (50.8-51.1)	11 300 (45.3)	18 704 (75.0)	15 486 (62.1)
Anterior cruciate ligament repair	14 306	34.1 (33.9-34.3)	4993 (34.9)	12 827 (89.7)	10 763 (75.2)
Gynecology					
Vaginal hysterectomy	14 904	45.1 (44.9-45.2)	14 904 (100.0)	11 779 (79.0)	11 240 (75.4)
Abdominal hysterectomy	9819	44.4 (44.3-44.6)	9819 (100.0)	8314 (84.7)	8021 (81.7)
Urology					
Transurethral prostatectomy	13 069	70.5 (70.4-70.7)	0	11 087 (84.8)	3577 (27.4)

[a] Source: Agency for Healthcare Research and Quality, Center for Delivery, Organization, and Markets, Healthcare Cost and Utilization Project; State Ambulatory Surgery Databases for 8 states: California, Florida, Georgia, Hawaii, Missouri, Nebraska, New York, and Tennessee, 2010.

Utilization

The mean age of patients undergoing 1 of the selected ambulatory surgical procedures ranged from 34.1 years (ACL repair) to 70.5 years (transurethral prostatectomy) (**Table 1**). Laparoscopic cholecystectomy was more likely to be performed on women (75.9%); laparoscopic repair of inguinal or femoral hernia was less likely to be performed on women (6.1%). At least 75.0% of each selected ambulatory surgical procedure was performed on patients from metropolitan areas, varying from a low of 75.0% for spine surgery to a high of 90.1% for laparoscopic inguinal or femoral hernia repairs.

Table 1 also shows variations in private insurance as the primary expected payer for ambulatory surgical procedures. More than 75% of ACL repairs and hysterectomies were billed to private insurance. In contrast, 27.4% of transurethral prostatectomies were billed to private insurance. With a mean patient age of 70.5 years, the majority of transurethral prostatectomies procedures were covered by Medicare.

Rates of Postsurgical Visits

Postsurgical Visits for CS-SSIs Within 14 Days

As shown in **Table 2**, the overall rate of postsurgical acute care visits for CS-SSIs within 14 days following the selected ambulatory surgical procedures was relatively low (3.09 [95% CI, 2.89-3.30] per 1000 ambulatory surgical procedures). The visit rates varied by type of surgery and ranged from 0.27 (95% CI, 0.09-0.65) per 1000 laparoscopic repairs of inguinal or femoral hernia to 6.44 (95% CI, 5.25-7.82) per 1000 vaginal hysterectomies, respectively. Two-thirds of the records for the postsurgical visits for CS-SSIs had a surgery-specific procedure or diagnosis code indicating the infection (eAppendix 4 in Supplement).

Rates of postsurgical visits for CS-SSIs following an open vs laparoscopic repair did not differ, except for repair of inguinal or femoral hernia. The 14-day postsurgical visit rate for CS-SSIs following laparoscopic inguinal or femoral hernia repair (0.27 [95% CI, 0.09-0.65] per 1000 hernia repairs) was significantly less than the 14-day postsurgical visit rate for CS-SSIs following open inguinal or femoral hernia repair (2.06 [95% CI, 1.72-2.46] per 1000 hernia repairs, $P < .001$). There was no difference in the 14-day rate of postsurgical visits for CS-SSIs following vaginal hysterectomies (6.44 [95% CI, 5.25-7.82] per 1000 hysterectomies) compared with abdominal hysterectomies (6.21 [95% CI, 4.80-7.92] per 1000 hysterectomies). The overall rate of postsurgical visits within 14 days for all causes, including CS-SSIs, was 19.99 (95% CI, 19.48-20.51) per 1000 ambulatory surgical procedures.

Postsurgical Visits for CS-SSIs Within 30 Days

The overall rate of postsurgical acute care visits for CS-SSIs across all surgical procedures increased from 3.09 (95% CI, 2.89-3.30) to 4.84 (95% CI, 4.59-5.10) per 1000 ambulatory surgical procedures when the time frame was extended to 30 days (Table 2). The 30-day rates of postsurgical visits for CS-SSIs also varied by type of surgery, ranging from a low of 0.75 (95% CI, 0.40-1.30) per 1000 laparoscopic repairs of inguinal or femoral hernia to a high of 11.38 (95% CI, 9.81-13.12) per 1000 open repairs of incisional or abdominal hernia. Similar to 14-day rates of postsurgical visits for CS-SSIs, there were no significant differences in 30-day rates of postsurgical visits for CS-SSIs following vaginal vs abdominal hysterectomies or open vs laparoscopic hernia repair, with 1 exception. The 30-day postsurgical visit rate for CS-SSIs following laparoscopic inguinal or femoral hernia repair (0.75 [95% CI, 0.40-1.30] per

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Table 2. Rates of Postsurgical Acute Care Visits for Clinically Significant Surgical Site Infections (CS-SSIs) and for All Causes Within 14 Days vs 30 Days of Ambulatory Surgery, 2010[a]

Type of Surgery	Index Surgical Procedures, No.	No. of Postsurgical Acute Care Visits for CS-SSIs (Rate/1000 Surgical Procedures) [95% CI]	
		Within 14 d	Within 30 d
Visits for CS-SSIs			
All surgery	284 098	877 (3.09) [2.89-3.30]	1376 (4.84) [4.59-5.10]
General surgery			
Laparoscopic cholecystectomy	92 195	275 (2.98) [2.65-3.35]	369 (4.00) [3.61-4.43]
Hernia repair			
Open inguinal or femoral	56 678	117 (2.06) [1.72-2.46]	169 (2.98) [2.56-3.46]
Laparoscopic inguinal or femoral	14 651	(0.27) [0.09-0.65][b]	11 (0.75) [0.40-1.30]
Open umbilical	20 231	54 (2.67) [2.03-3.45]	98 (4.84) [3.96-5.87]
Laparoscopic umbilical	4528	21 (4.64) [2.96-6.95]	26 (5.74) [3.84-8.27]
Open incisional or abdominal	15 819	81 (5.12) [4.10-6.33]	180 (11.38) [9.81-13.12]
Laparoscopic incisional or abdominal	2969	19 (6.40) [3.99-9.77]	24 (8.08) [5.32-11.80]
Orthopedic or neurosurgical			
Spine surgery	24 929	64 (2.57) [2.00-3.25]	140 (5.62) [4.74-6.60]
Anterior cruciate ligament repair	14 306	35 (2.45) [1.73-3.36]	62 (4.33) [3.35-5.51]
Gynecology			
Vaginal hysterectomy	14 904	96 (6.44) [5.25-7.82]	122 (8.19) [6.83-9.73]
Abdominal hysterectomy	9819	61 (6.21) [4.80-7.92]	72 (7.33) [5.79-9.17]
Urology			
Transurethral prostatectomy	13 069	14 (1.07) [0.61-1.75]	23 (1.76) [1.15-2.59]
Visits for all causes			
All surgery	284 098	5679 (19.99) [19.48-20.51]	9551 (33.62) [32.96-34.29]

Abbreviation: CS-SSI, clinically significant surgical site infection.

[a] Source: Agency for Healthcare Research and Quality, Center for Delivery, Organization, and Markets, Healthcare Cost and Utilization Project; State Ambulatory Surgery Databases and State Inpatient Databases for 8 states: California, Florida, Georgia, Hawaii, Missouri, Nebraska, New York, and Tennessee, 2010.

[b] Counts for cell sizes less than 11 have been suppressed to preserve the confidentiality of the data.

1000 hernia repairs) was significantly less than the 30-day postsurgical visit rate for CS-SSIs following open inguinal or femoral hernia repair (2.98 [95% CI, 2.56-3.46] per 1000 hernia repairs ($P < .001$). The overall rate of postsurgical visits within 30 days for all causes including CS-SSIs was 33.62 (95% CI, 32.96-34.29) per 1000 ambulatory surgical procedures.

Follow-up Time for Postsurgical Visits

Two-thirds (63.7%) of all postsurgical acute care visits for CS-SSIs following these ambulatory surgical procedures occurred in the first 14 days (877 visits within 14 days [3.09 per 1000 ambulatory surgical procedures] compared with 1376 visits within 30 days [4.84 per 1000 ambulatory surgical procedures]). This pattern was similar for each type of surgery except laparoscopic repair of inguinal or femoral hernia, open repair of incisional or abdominal hernia, and spine surgery; the postsurgical visit rate for CS-SSIs more than doubled between 14 and 30 days (ie, less than half of the postsurgical visits for CS-SSIs for these procedures occurred in the first 14 days).

Location of Postsurgical Visits

More than 90% of postsurgical acute care visits for CS-SSIs within 14 days were treated in the inpatient setting (95% CI, 91.3%-94.7%), and nearly 90% of postsurgical acute care visits for CS-SSIs within 30 days were treated in the inpatient setting (95% CI, 86.4%-89.9%) (**Table 3**). Similar to the variation in rates of CS-SSIs by type of surgery, the proportion of postsurgical inpatient visits for CS-SSIs also varied by type of surgery. For CS-SSI visits within 14 days, the portion occurring in the inpatient hospital setting ranged from 75.0% (95% CI, 28.4%-97.2%) to 100.0% (95% CI, 87.8%-100.0%) for laparoscopic repair of inguinal or femoral hernia and laparoscopic repair of incisional or abdominal hernia, respectively. For CS-SSI visits within 30 days, the portion occurring in the inpatient hospital setting ranged from 72.7% (95% CI, 43.5%-91.7%) to 96.7% (95% CI, 92.4%-98.9%) for laparoscopic repair of inguinal or femoral hernia and for vaginal hysterectomy, respectively.

Discussion

Our findings affirmed that the rate of clinically important infections following ambulatory surgery was low, despite documented poor infection control practices in ambulatory surgery centers[14] and in contrast to higher rates of infections following inpatient operations.[1,2] However, because of the large number of ambulatory surgical procedures performed annually, in absolute terms, a substantial number of patients undergoing ambulatory surgical procedures develop clinically sig-

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Table 3. Distribution of Postsurgical Acute Care Visits for Clinically Significant Surgical Site Infections (CS-SSIs) Within 14 Days vs 30 Days of Ambulatory Surgery by Hospital Setting, 2010[a]

Type of Surgery	Index Surgical Procedures, No.	No. (%) [95% CI]			
		Within 14 d		Within 30 d	
		Inpatient Hospitalization	Ambulatory Surgery Visit	Inpatient Hospitalization	Ambulatory Surgery Visit
All surgery	284 098	817 (93.2) [91.3-94.7]	60 (6.8) [5.3-8.7]	1214 (88.2) [86.4-89.8]	162 (11.8) [10.2-13.6]
General surgery					
Laparoscopic cholecystectomy	92 195	262 (95.3) [92.3-97.3]	13 (4.7) [2.7-7.7]	335 (90.8) [87.5-93.4]	34 (9.2) [6.6-12.5]
Hernia repair					
Open inguinal or femoral	56 678	97 (82.9) [75.3-88.9]	20 (17.1) [11.1-24.7]	135 (79.9) [73.4-85.4]	34 (20.1) [14.6-26.6]
Laparoscopic inguinal or femoral	14 651	(75.0) [28.4-97.2][b]	(25.0) [2.8-71.6][b]	(72.7) [43.5-91.7][b]	(27.3) [8.3-56.5][b]
Open umbilical	20 231	52 (96.3) [88.6-99.2]	(3.7) [0.8-11.4][b]	81 (82.7) [74.3-89.1]	17 (17.3) [10.9-25.7]
Laparoscopic umbilical	4528	19 (90.5) [72.8-98.0]	(9.5) [2.0-27.2][b]	24 (92.3) [77.5-98.4]	(7.7) [1.6-22.5][b]
Open incisional or abdominal	15 819	76 (93.8) [87.0-97.6]	(6.2) [2.4-13.0][b]	156 (86.7) [81.1-91.0]	24 (13.3) [9.0-18.9]
Laparoscopic incisional or abdominal	2969	19 (100) [87.8-100]	0 (0.0) [0.0-12.2]	21 (87.5) [70.3-96.4]	(12.5) [3.6-29.7][b]
Orthopedic or neurosurgical					
Spine surgery	24 929	59 (92.2) [83.7-97.0]	(7.8) [3.0-16.3][b]	125 (89.3) [83.4-93.6]	15 (10.7) [6.4-16.6]
Anterior cruciate ligament repair	14 306	31 (88.6) [75.1-96.0]	(11.4) [4.0-24.9][b]	49 (79.0) [67.7-87.7]	13 (21.0) [12.3-32.3]
Gynecology					
Vaginal hysterectomy	14 904	94 (97.9) [93.5-99.6]	(2.1) [0.4-6.5][b]	118 (96.7) [92.4-98.9]	(3.3) [1.1-7.6][b]
Abdominal hysterectomy	9819	59 (96.7) [89.9-99.3]	(3.3) [0.7-10.1][b]	68 (94.4) [87.3-98.1]	(5.6) [1.9-12.7][b]
Urology					
Transurethral prostatectomy	13 069	13 (92.9) [71.2-99.2]	(7.1) [0.8-28.8][b]	20 (87.0) (69.1-96.2]	(13.0) [3.8-30.9][b]

[a] Source: Agency for Healthcare Research and Quality, Center for Delivery, Organization, and Markets, Healthcare Cost and Utilization Project; State Ambulatory Surgery Databases and State Inpatient Databases for 8 states: California, Florida, Georgia, Hawaii, Missouri, Nebraska, New York, and Tennessee, 2010.

[b] Counts for cell sizes less than 11 have been suppressed to preserve the confidentiality of the data.

nificant postoperative infections. Most of these infections occurred within 2 weeks after surgery and resulted in hospital admission. Therefore, reporting rates at both 14 and 30 days are relevant, because routine follow-up visits for these procedures are frequently scheduled outside this 14-day time frame. For example, studies have shown that routine follow-up was 3 weeks for inguinal hernia, laparoscopic cholecystectomy, and anorectal surgical procedures, and a range of 2 to 4 weeks for adenotonsillectomy.[18-20] Our findings suggest that earlier access to a clinician or member of the surgical team (eg, telephone check-in prior to 2 weeks) may help identify and treat these infections early and reduce overall morbidity.

Given the paucity of information available regarding postoperative ambulatory infection rates, this study provides important baseline information regarding current infection rates following ambulatory surgery. The patterns and substantial variations in rates of CS-SSIs across different types of ambulatory surgical procedures emphasize the importance of reporting and studying rates of adverse events by surgical specialty. In addition to producing up-to-date and surgical procedure-specific infection rates for a range of surgical procedures not found in previous studies, our analysis benefited from the use of multistate, all-payer data sources using all inpatient and ambulatory surgery encounters occurring at hospital-owned facilities. Rates of CS-SSIs were relatively low, but because the CS-SSIs entailed hospitalization or additional procedures to treat infections, their clinical importance may be substantial.

With only a single exception, CS-SSI rates following laparoscopic procedures were not lower than those for open procedures. This unexpected finding may be explained several ways. Unmeasured clinical confounders between the groups such as differing body mass index or revisional surgery could have been present. Because low-risk patients selectively undergo surgery in ambulatory settings, this seems unlikely. It is more likely that because CS-SSI rates were relatively low, the power to detect differences between groups undergoing open vs laparoscopic surgery might have been insufficient.

With the exception of hernia repair, our findings are not directly comparable to prior published articles on SSIs after ambulatory surgery because those studies were mostly conducted outside the United States, examined small study

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populations, or used contrasting data sources such as medical records, physician and patient surveys, and patient registries. Many of these studies were from the 1990s and early 2000s and may not reflect current surgical practice. Prior studies assessed either surgical procedures different from those we examined (eg, hand,[21,22] laparoscopic appendectomy,[23] dermatology[24]) or diagnosis-specific procedures[25-27] (eg, cancer-related surgery[28]). Studies of all hernia repair types combined reported SSI rates between 0.5%[29] and 0.7%.[26] Rates of SSIs specific to inguinal hernia repair range from 1%[30-33] to 5%.[27,34]

Among the limitations of using the selected HCUP data was that the 8 states, although geographically dispersed, may not reflect rates in other regions of the country. The data sets only capture postsurgical visits for CS-SSIs in hospital-owned settings (ambulatory surgery or inpatient) and exclude CS-SSIs subsequently managed in physician offices and emergency departments. Although we did not capture the universe of postoperative infections, those we did analyze represent serious infections that caused substantial morbidity and were costly to manage. We showed that 90% of these serious infections were treated in the hospital after ambulatory surgery. Quality improvement initiatives targeting reduction in the incidence of these infections could substantially benefit patients and reduce health care costs. Previous research revealed frequent, substantial breaches in infection control practices in ambulatory surgery centers,[14] suggesting that more rigorous attention to infection control might reduce the absolute number of CS-SSIs we observed.

Our findings do not include CS-SSIs following ambulatory surgical procedures performed at nonhospital-owned ambulatory surgery settings. However, the subanalysis of HCUP State Ambulatory Surgery Databases data for 2 states with complete reporting of ambulatory surgery encounters in all facilities regardless of hospital ownership demonstrates that this is not a significant limitation. The hospital-owned ambulatory surgery settings accounted for more than two-thirds of the ambulatory procedures of interest (eAppendix 3 in Supplement).

Last, identifying postsurgical CS-SSIs requires using all diagnoses and procedures reported on the record. Several studies have demonstrated the validity of coding for SSIs using administrative data.[35-38] In addition, our sensitivity analysis showed that 28.2% of postsurgical visits for CS-SSIs within 14 days were identified using any listed procedure codes specific to an infection, 38.9% were identified using any listed infection diagnosis codes specific to a surgical procedure, and 32.9% were identified using any listed procedures or diagnosis codes indicating an infection (eAppendix 4 in Supplement). These results suggest that the algorithm is robust and that the infections and symptoms are not related to other conditions.

Conclusions

Among patients in 8 states the rates of CS-SSIs were relatively low. However, given how common ambulatory surgery is, the absolute number of patients with these complications is substantial. Prior studies showing significant lapses in infection control practices at ambulatory surgery centers suggest that quality improvement efforts may facilitate reducing CS-SSIs following ambulatory surgery.

ARTICLE INFORMATION

Author Contributions: Drs Owens and Steiner and Ms Barrett had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.
Study concept and design: Owens, Barrett, Steiner.
Acquisition of data: Owens, Barrett, Steiner.
Analysis and interpretation of data: All authors.
Drafting of the manuscript: Owens, Barrett, Raetzman.
Critical revision of the manuscript for important intellectual content: All authors.
Statistical analysis: Owens, Barrett, Raetzman, Steiner.
Administrative, technical, and material support: Owens, Steiner.
Study supervision: Steiner.

Conflict of Interest Disclosures: All authors have completed and submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest and none were reported.

Funding/Support: This study was funded by the Agency for Healthcare Research and Quality (AHRQ) under a contract to Truven Health Analytics to develop and support the Healthcare Cost and Utilization Project (HCUP) (contract HHSA-290-2013-00002-C).

Role of the Sponsor: The AHRQ had no role in the design and conduct of the study; the collection, management, analysis, and interpretation of the data; the preparation, review, or approval of the manuscript; or the decision to submit the manuscript for publication.

Disclaimer: The views expressed in this article are those of the authors and do not necessarily reflect those of the AHRQ or the US Department of Health and Human Services.

Additional Contributions: We would like to thank 8 data organizations that contributed data to the HCUP that were used in this study: the California Office of Statewide Health Planning and Development; Florida Agency for Health Care Administration; Georgia Hospital Association; Hawaii Health Information Corporation; Missouri Hospital Industry Data Institute; Nebraska Hospital Association; New York State Department of Health; and Tennessee Hospital Association. In addition, we would like to thank the following individuals, who were compensated for their contributions: Minya Sheng, MS (Truven Health Analytics), and Tim Kenney, MA (Kenny IS Consulting), for the statistical programming; Lorena Lopez-Gonzalez, PhD (Truven Health Analytics), for the literature review; and Linda Lee, PhD (Truven Health Analytics), for editorial assistance.

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