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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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 patients1,2 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 States12 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 discectomy 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 surgical 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...
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.

Post-surgical 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 (Appendix 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 post-operative infection.

We computed rates of ambulatory surgical visits or post-surgical inpatient stays for all causes (including CS-SSIs) to indicate the relative importance of SSIs as a reason for post-surgical 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 χ² test at P < .01.

Results
The Figure displays the selection of index ambulatory surgical procedures. We extracted all ambulatory surgical 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.

Appendix 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.
Table 1. Characteristics of Patients Undergoing Ambulatory Surgical Procedures in Hospital-Owned Settings, 2010*

<table>
<thead>
<tr>
<th>Type of Surgery</th>
<th>Index Surgical Procedures, No.</th>
<th>Age, Mean (95% CI), y</th>
<th>Women</th>
<th>Metropolitan Residence</th>
<th>Primary Expected Payer: Private</th>
</tr>
</thead>
<tbody>
<tr>
<td>General surgery</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laparoscopic cholecystectomy</td>
<td>92 195</td>
<td>47.7 (47.6-47.8)</td>
<td>69 935 (75.9)</td>
<td>75 692 (82.1)</td>
<td>56 854 (61.7)</td>
</tr>
<tr>
<td>Hernia repair</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Open inguinal or femoral</td>
<td>56 678</td>
<td>58.2 (58.1-58.4)</td>
<td>5938 (10.5)</td>
<td>49 615 (87.5)</td>
<td>26 136 (46.1)</td>
</tr>
<tr>
<td>Laparoscopic inguinal or femoral</td>
<td>14 651</td>
<td>54.4 (54.2-54.7)</td>
<td>900 (6.1)</td>
<td>13 207 (90.1)</td>
<td>8840 (60.3)</td>
</tr>
<tr>
<td>Open umbilical</td>
<td>20 231</td>
<td>49.4 (49.2-49.6)</td>
<td>6276 (31.0)</td>
<td>17 643 (87.2)</td>
<td>12 819 (63.4)</td>
</tr>
<tr>
<td>Laparoscopic umbilical</td>
<td>4528</td>
<td>51.0 (50.6-51.4)</td>
<td>1959 (43.3)</td>
<td>3953 (87.3)</td>
<td>2787 (61.6)</td>
</tr>
<tr>
<td>Open incisional or abdominal</td>
<td>15 819</td>
<td>54.0 (53.8-54.2)</td>
<td>8925 (56.4)</td>
<td>13 480 (85.2)</td>
<td>8299 (52.5)</td>
</tr>
<tr>
<td>Laparoscopic incisional or abdom</td>
<td>2969</td>
<td>55.5 (55.0-56.0)</td>
<td>1757 (59.2)</td>
<td>2584 (87.0)</td>
<td>1563 (52.6)</td>
</tr>
<tr>
<td>Orthopedic or neurosurgical</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spine surgery</td>
<td>24 929</td>
<td>50.9 (50.8-51.1)</td>
<td>11 300 (45.3)</td>
<td>18 704 (75.0)</td>
<td>15 486 (62.1)</td>
</tr>
<tr>
<td>Anterior cruciate ligament repair</td>
<td>14 306</td>
<td>34.1 (33.9-34.3)</td>
<td>4993 (34.9)</td>
<td>12 827 (89.7)</td>
<td>10 763 (75.2)</td>
</tr>
<tr>
<td>Gynecology</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vaginal hysterectomy</td>
<td>14 904</td>
<td>45.1 (44.9-45.2)</td>
<td>14 904 (100.0)</td>
<td>11 779 (79.0)</td>
<td>11 240 (75.4)</td>
</tr>
<tr>
<td>Abdominal hysterectomy</td>
<td>9819</td>
<td>44.4 (44.3-44.6)</td>
<td>9819 (100.0)</td>
<td>8314 (84.7)</td>
<td>8021 (81.7)</td>
</tr>
<tr>
<td>Urology</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transurethral prostatectomy</td>
<td>13 069</td>
<td>70.5 (70.4-70.7)</td>
<td>11 087 (88.4)</td>
<td>3577 (27.4)</td>
<td></td>
</tr>
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</table>


**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 (61.7%). 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**

Post surgical 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 hysterectomies) 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 hysterectomies). There was no difference in the 14-day rate of postsurgical visits for CS-SSIs following open inguinal or femoral hernia repair (2.06 [95% CI, 1.72-2.46] 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.

Post surgical visits for CS-SSIs within 30 days 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
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 and in contrast to higher rates of infections following inpatient operations. 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-
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 samples, or were limited to a single surgical procedure. Given the paucity of information available regarding postoperative infection rates, this study provides important baseline information regarding current 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.

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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 as-
essed either surgical procedures different from those we ex-
amined (eg, hand,21,22 laparoscopic appendectomy,23
dermatology24) or diagnosis-specific procedures25-27 (eg, cancer-
related surgery28). Studies of all hernia repair types combined
reported SSI rates between 0.5%29 and 0.7%,30 Rates of SSIs spe-
cific to inguinal hernia repair range from 1%30-33 to 5%.32-34

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 set-
tings (ambulatory surgery or inpatient) and exclude CS-SSIs
subsequently managed in physician offices and emergency de-
partments. Although we did not capture the universe of post-
operative 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 re-
duce health care costs. Previous research revealed frequent,
substantial breaches in infection control practices in ambula-
tory surgery centers,14 suggesting that more rigorous atten-
dice and impact on hospital utilization and

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