The effect of Surgical Care Improvement Project measures on national trends on surgical site infections in open vascular procedures

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Objective: **The Surgical Care Improvement Project (SCIP) is a national initiative to reduce surgical complications, including postoperative surgical site infection (SSI), through protocol-driven antibiotic usage. This study aimed to determine the effect SCIP guidelines have had on in-hospital SSIs after open vascular procedures.**

Methods: **The Nationwide Inpatient Sample (NIS) was retrospectively analyzed using International Classification of Diseases, Ninth Revision, diagnosis codes to capture SSIs in hospital patients who underwent elective carotid endarterectomy, elective open repair of an abdominal aortic aneurysm (AAA), and peripheral bypass. The pre-SCIP era was defined as 2000 to 2005 and post-SCIP was defined as 2007 to 2010. The year 2006 was excluded because this was the transition year in which the SCIP guidelines were implemented. Analysis of variance and χ^2 testing were used for statistical analysis.**

Results: **The rate of SSI in the pre-SCIP era was 2.2% compared with 2.3% for carotid endarterectomy ($P = .06$). For peripheral bypass, both in the pre- and post-SCIP era, infection rates were 0.1% ($P = .22$). For open, elective AAA, the rate of infection in the post-SCIP era increased significantly to 1.4% from 1.0% in the pre-SCIP era ($P < .001$). Demographics and in-hospital mortality did not differ significantly between the groups.**

Conclusions: **Implementation of SCIP guidelines has made no significant effect on the incidence of in-hospital SSIs in open vascular operations; rather, an increase in SSI rates in open AAA repairs was observed. Patient-centered, bundled approaches to care, rather than current SCIP practices, may further decrease SSI rates in vascular patients undergoing open procedures. (J Vasc Surg 2014;60:1635-9.)**

The Surgical Care Improvement Project (SCIP) was created as one of the Joint Commission Core Measures to improve hospital quality. SCIP is the crux of an ongoing national initiative to improve the safety and quality of care provided to patients and is a coordinated effort stemming from a partnership between the Centers for Medicare and Medicaid Services (CMS) and the Centers for Disease Control and Prevention (CDC).[1]

In 2003, a core measure, "Surgical Infection Prevention," was initiated and expanded; by July 2006, this measure, known as "SCIP," became an integral part of surgical care.[1] SCIP is a function of a steering committee that incorporates the CMS, the CDC, the Joint Commission, and the Agency for Healthcare Research and Quality (AHRQ). The stated goal of SCIP is to "reduce surgical mortality and morbidity, ostensibly by 25% within 5 years."[1] In an attempt to fulfil this goal, SCIP provided recommendations on antibiotic use in the preoperative, perioperative, and postoperative periods to reduce the rate of surgical site infections (SSIs).

SCIP details explicitly the duration and timing of antibiotic prophylaxis to be ≤60 minutes before incision (regardless of the surgery type), the type of antibiotic that is to be given, and insists on the prompt discontinuation of antibiotics postoperatively, especially in elective cases with no known infective issues. The single dose of antibiotics preoperatively serves to prevent skin or soft tissue infection that may arise from the incision itself and does not directly affect organ or peritoneal cavity infections that are related to the original pathology.

Because SCIP has been linked to financial reimbursement by the CMS, mandatory compliance in hospitals has followed its implementation. The effect of SCIP guidelines on vascular SSIs, however, has not been evaluated. This study aimed to determine the effect of SCIP antibiotic prescribing practices on in-hospital SSI rates in patients who underwent open, elective vascular procedures, including open abdominal aortic aneurysm (AAA) repair, carotid endarterectomy (CEA), and peripheral bypass.

METHODS

Database and selection. A retrospective analysis was completed using the Nationwide Inpatient Sample (NIS), a part of the Health Care Utilization Project (HCUP)

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Table I. International Classification of Diseases, Ninth Revision (*ICD-9*), diagnosis and procedure codes used to select patients from the Nationwide Inpatient Sample (NIS)

ICD-9 code	*Description*
Diagnosis codes	
441.4	AAA without mention of rupture
441.9	Aortic aneurysm, not otherwise specified
998.59	SSI
Procedure codes	
38.34	AAA: aorta resection and anastomosis
38.44	AAA: replacement of abdominal aorta
38.64	AAA: excision of aorta
39.52	AAA: other repair of aneurysm
38.12	CEA: head and neck endarterectomy
39.29	Bypass: vascular shunt and bypass

AAA, Abdominal aortic aneurysm; *CEA,* carotid endarterectomy; *SSI,* surgical site infection.

that is maintained by the AHRQ. The NIS is the largest all-payer inpatient database and includes a stratified 20% random sample of all nonfederal inpatient hospital admissions throughout the United States. Clinical records between 2000 and 2010 were derived using the International Classification of Diseases, Ninth Revision (ICD-9), diagnosis and procedure codes to include patients who underwent treatment primarily for elective, open vascular procedures, including open, elective AAA repair, CEA, and peripheral bypass with or without SSIs (Table I).[2] ICD-9 codes for endovascular AAA repair were excluded because we could not determine from the ICD-9 codes which patients underwent a percutaneous endovascular repair and those who underwent femoral cutdown.

Variables. The independent variable was year, ranging from 2000 to 2005 and from 2007 to 2010. The year 2006 was excluded because this was the transition year in which the SCIP guidelines were fully implemented (Table II).[1] Demographic covariates included age, gender, and race. Clinical covariates included SSI, in-hospital mortality, median length of stay (LOS) in days, and median hospital charges adjusted for 2010 US dollars using the Consumer Price Index. Hospital covariates included hospital size, geographic region, rural vs urban, or teaching vs nonteaching hospitals. Any patients with pre-existing infections were excluded from the sample. Because this was a database study, it was exempt from the Investigational Review Board, and no identifiable patient data were used; hence, no patient consent was necessary.

Statistical analysis. Statistical analysis was completed using analysis of variance for continuous variables (ie, age) and χ^2 for categoric variables (ie, gender, race, and mortality). The Mann-Whitney *U* test was used for LOS and total charges, and the one-tailed χ^2 test with Yates correction was used to compare the rate of SSI before and after the initiation of SCIP antibiotic guidelines. Data analysis and management were completed using SPSS 21.0 software (IBM Corp, Armonk, NY). Statistical significance was set at $P < .05$. Values are presented as mean ± standard deviation for age or as median values for LOS and total charges. A Kendall-Mann trend analysis was completed to assess the trend in SSI rates during the study period.

Table II. Surgical Care Improvement Project (*SCIP*) core measure set (implemented in 2006)

Measure ID	*Description*
SCIP Inf-1	Prophylactic antibiotic 1 hour before incision
SCIP Inf-2	Prophylactic antibiotic selection for surgical patients
SCIP Inf-3	Prophylactic antibiotics discontinued ≤24 hours after surgery end time
SCIP Inf-4	Cardiac surgery patients with controlled postoperative blood glucose
SCIP Inf-6	Surgery patients with appropriate hair removal (clipping)
SCIP Inf-9	Urinary catheter removed on postoperative day 1
SCIP Inf-10	Surgery patients with perioperative temperature management
SCIP Card-2	Surgery patients on β-blocker receive β-blocker perioperatively
SCIP VTE-2	Appropriate venous thromboembolism prophylaxis 24 hours before surgery and 24 hours after surgery

Inf, Infection; *VTE,* venous thromboembolism.

RESULTS

The demographics and SSI status of patients who underwent CEA, AAA repair, or peripheral bypass separated by the development of an SSI in the NIS from 2000 to 2005 are s detailed in Table III. The demographics and SSI status of patients who underwent CEA, AAA repair, or peripheral bypass, separated by the development of an SSI in the NIS from 2007 to 2010 are detailed in Table IV.

There was no difference in demographics, comorbidities, or in-hospital mortality when patients with and without SSI from 2000 to 2005 (pre-SCIP era) were compared with those with and without SSI from 2007 to 2010 (post-SCIP era). Furthermore, SSI rates were not affected by hospital covariates such as hospital size, geographic region, rural vs urban, or teaching vs nonteaching hospitals.

For CEA, the rate of SSI in the pre-SCIP era was 2.2% compared with 2.3% in the post-SCIP era ($P = .06$). In the peripheral bypass group, the rate of SSI in the pre-SCIP era was 0.1% and stayed at 0.1% in the post-SCIP era ($P = .22$). However, for open, elective AAA, the rate of infection in the post-SCIP era increased significantly, from 1.0% in the pre-SCIP era to 1.4% ($P < .001$). Table V summarizes these results.

The Kendall-Mann trend analysis was completed to assess the increase in SSI for patients who underwent open AAA repair in the post-SCIP era compared with the pre-SCIP era. The analysis found a significant increase, with a correlation coefficient of 0.22 ($P < .05$).

DISCUSSION

Across the United States ~1 million SSIs occur annually, resulting in 3.7 million extra hospital days and an added cost in excess of $1.6 billion.[3-5] Patients who develop SSIs are 60% more likely to be admitted to the

Table III. Demographics and surgical site infection (*SSI*) status of patients who underwent carotid endarterectomy (*CEA*), abdominal aortic aneurysm (*AAA*) repair, or peripheral bypass separated by the development of an SSI in the Nationwide Inpatient Sample (NIS) from 2000 to 2005

Variable	*CEA+ SSI (n = 254)*	*CEA− SSI (n = 172,098)*	*AAA+ SSI (n = 311)*	*AAA− SSI (n = 30,205)*	*Bypass+ SSI (n = 2386)*	*Bypass− SSI (n = 106,885)*
Age, mean ± SD, years	71 ± 10	71 ± 9	72 ± 8	72 ± 8	67 ± 13	68 ± 12
Female, %	41	43	28	23	44	41
Caucasian, %	85	90	88	91	73	76
COPD, %	31	20	41	37	24	25
Diabetes mellitus, %	23	25	9	11	18	24
LOS, median (IQR), days	17 (6-25)	2 (1-3)	17 (9-26)	7 (5-10)	17 (10-25)	6 (3-11)
In-hospital mortality, %	12	1	19	4	7	3
Total charges, median (IQR), $	84,670 ($36,240-$199,549)	15,139 ($13,401-$32,852)	102,375 ($39,394-$172,905)	41,091 ($38,505-$93,275)	69,877 ($49,142-$184,710)	30,253 ($23,700-$74,565)

COPD, Chronic obstructive pulmonary disease; *IQR,* interquartile range; *LOS,* length of stay; *SD,* standard deviation.

Table IV. Demographics and surgical site infection (*SSI*) status of patients who underwent carotid endarterectomy (*CEA*), abdominal aortic aneurysm (*AAA*) repair, or peripheral bypass separated by the development of an SSI in the Nationwide Inpatient Sample (NIS) from 2007 to 2010

Variable	*CEA+ SSI (n = 123)*	*CEA− SSI (n = 91,302)*	*AAA+ SSI (n = 134)*	*AAA− SSI (n = 9163)*	*Bypass+ SSI (n = 1243)*	*Bypass− SSI (n = 52,612)*
Age, mean ± SD, years	70 ± 10	71 ± 10	71 ± 9	71 ± 9	66 ± 14	67 ± 13
Female, %	35	42	30	27	42	37
Caucasian, %	79	88	88	88	75	74
COPD, %	21	22	46	35	25	27
Diabetes mellitus, %	28	28	11	15	17	26
LOS, median (IQR), days	15 (7-28)	1 (1-3)	19 (10-33)	7 (5-10)	15 (8-27)	5 (3-10)
In-hospital mortality, %	7	0	11	4	5	2
Total charges, median (IQR), $	140,876 ($61,851-$246,967)	23,236 ($15,977-$38,798)	159,147 ($72,437-$363,191)	69,842 ($46,882-$112,722)	112,726 ($62,539-$215,503)	49,490 ($29,489-$89,949)

IQR, Interquartile range; *LOS,* Length of stay; *SD,* standard deviation.

intensive care unit, are readmitted to hospital five times more frequently, and have a two times higher mortality rate compared with their non-SSI counterparts.[3]

To decrease rates of surgical complications such as SSI, SCIP was developed by CMS and implemented in 2006. A major component of the SCIP initiative focuses on standardizing timing, type, and duration of antibiotics to decrease rates of SSI in surgical patients. This protocol-driven measure was primarily mandated to decrease antibiotic administration variation across the nation and eliminate institutional error rates related to antibiotic timing and duration.[4,5]

Open vascular procedures are considered "clean" cases and warrant a single dose of cefazolin 60 minutes before incision for most surgical procedures, according to SCIP guidelines. Cefazolin has been used for vascular procedures since 1978 when Kaiser et al[6] reported a decrease in SSIs in patients administered preoperative cefazolin compared with placebo. However, before the SCIP initiative, some vascular surgeons administered additional doses of cefazolin after the procedure or included other antibiotics, such as ampicillin/sulbactam, or both. With the surge of methicillin-resistant *Staphylococcus aureus* (MRSA), studies have attempted to decipher if additional antibiotics or routine MRSA screening with prophylaxis decreases infection rates.[7,8] These studies concluded that adding anti-MRSA agents to current antibiotic regimens did not reduce rates and that up to 57% of patients who developed an MRSA infection were MRSA-free on admission, making screening futile.[7,8]

These data, in conjunction with the fact that hospital adherence to SCIP quality care measures is directly linked to hospital reimbursement, have ensured that SCIP protocols in their current form are implemented nationally.[1] These SCIP initiatives are expensive to implement and require a multidisciplinary approach to achieve the necessary 95% compliance with core measures.[4,5,9] Hence, determining if these SCIP measures are indeed positively affecting surgical complication rates and are therefore cost-effective is important. Our results, which showed no improvement in the SSI rate for CEA or open bypass along with an increase in the SSI rate in open AAA repair, would seem to suggest that SCIP has not had a positive effect in this area as hoped.

With few exceptions made for colorectal or cardiovascular surgery, SCIP guidelines are universally applied to patients who undergo surgical procedures. Hawn et al[10] found that SSI risk varies by patient characteristics and by procedural type; hence, applying SCIP guidelines in their current form to all-comers undergoing open vascular procedures may be inappropriate.[7,10] Several factors have been

Table V. Breakdown of surgical site infections (*SSIs*) by year between 2000 and 2005 and between 2007and 2010 for patients who underwent carotid endarterectomy (*CEA*), elective repair of an unruptured abdominal aortic aneurysm (*AAA*), and peripheral bypass[a]

Procedure	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*	*2007*	*2008*	*2009*	*2010*
CEA										
SSI	446	384	435	412	369	340	364	328	300	251
Total	20,230	19,700	19,539	18,062	16,558	15,183	13,999	14,193	13,354	12,311
%	2.2	1.9	2.2	2.3	2.2	2.2	2.6	2.3	2.2	2.0
AAA[b]										
SSI	51	52	60	57	50	41	45	20	42	27
Total	7572	5563	4958	4698	4156	3570	2616	2597	2302	1782
%	0.7	0.9	1.2	1.2	1.2	1.1	1.7	0.8	1.8	1.5
Bypass										
SSI	42	35	48	44	37	48	36	39	29	19
Total	30,277	30,190	30,979	29,440	26,285	25,188	24,628	24,541	22,592	19,665
%	0.1	0.1	0.2	0.1	0.1	0.2	0.1	0.2	0.1	0.1

[a]Pooled values between 2000 and 2005 and between 2007 and 2010 were compared using χ^2 with Yates correction, with $P < .05$ indicating significance.
[b]$P < .05$.

correlated with increased infection rates, including surgical site location, body mass index (BMI), adherence to antiseptic shower requirements, maximum intraoperative blood glucose level, and the length of operation or hospital stay.[7] Furthermore, vascular interventions may directly affect the rate of blood flow to the area, which may increase the risk of infection and healing propensity.

Patients undergoing open AAA surgery are subject to a long operation time, periods of hypotension, and bowel manipulation that may put them at increased risk of SSIs. Our results show that patients with open AAA repair had an increase in in-hospital SSI rates after the SCIP guidelines were implemented, illustrating the notion that the "one size fits all" dictum of SCIP is perhaps not adequate and potentially harmful in this patient population.

The overall success of SCIP has been varied. Colorectal studies have reported data that shows increased compliance with SCIP measures does not correlate with a decrease in SSI.[11] Stulberg et al[12] reported an increase in infection rates for colorectal patients with increased compliance with SCIP measures during a 2-year period. There are two possible reasons for an increase in infection rates even with adherence to SCIP measures. A pharmacokinetic study found that in patients with a BMI >40 kg/m^2, the standard 2 grams of cefazolin in conjunction with appropriate redosing at 3 hours was insufficient to achieve therapeutic levels of the antibiotic in tissue.[4,5,9] Current SCIP guidelines do not incorporate patient factors such as BMI into dosing regimens.

Another possibility is the evolving antibiotic resistance patterns within the United States. Studies have found *Escherichia coli* has decreased susceptibility to first-generation cephalosporin antibiotics, likely due to increased use of the drug. The efficacy of cefazolin, the current SCIP drug of choice, has diminished during the last 20 years, which may account for SSI rate results.[4,5,9]

Our results indicate that a "one-size fits all" antibiotic approach mandated by SCIP, with significant reimbursement implications, may be inappropriate for some open vascular procedures. Instead, a patient-centered "bundle approach" may be a better strategy to decrease SSI rates in vascular patients undergoing procedures. Our study also noted that charges have substantially increased in patients with SSIs between the pre-SCIP and post-SCIP era and primarily reflect the increased LOS and additional interventions that are necessary in these patients.

Waits et al[13] described a bundled approach to care in a multi-institutional study of colorectal patients that included points for normothermia, SCIP-delineated antibiotic prophylaxis, bowel preparation, perioperative glycemic control, minimally invasive surgery, and a short operation duration. The authors reported a low 2% infection rate for patients that met all of the bundle score criteria and up to a 17.5% infection rate for patients that met only one element of the score.[13] Perhaps a bundled score for open vascular surgery operations may achieve a similar lower SSI rate in the open AAA population. This would include timely antibiotic prophylaxis, antiseptic showering, glycemic control perioperatively, normothermia, and adequate alcohol-based skin preparation before the incision.[4,5,9]

This study is limited by its retrospective design and use of a database. Although the NIS-HCUP is a validated database constructed by the federal government to evidence decision making and health care policy, data are entered based on ICD-9 codes, which has inherent flaws. Given that only hospital admission data are entered, long-term follow-up of patients is not possible; hence, the infection rates reported in this study are that of the in-patient admission in which the surgery occurred. We thus may have under-reported overall SSI rates given that a patient may return as an out patient with a SSI not noted before the initial discharge.

Another limitation is that because of the deidentified database nature of this study, determining exactly how adherent hospitals were to SCIP guidelines >2006 is not possible. Exclusion of the year 2006 was an attempt to mitigate this limitation because most hospitals by the end of the 2006 would be adhering to SCIP guidelines to ensure appropriate reimbursement. The NIS does not track readmissions, and it is likely that some of the patients who developed SSI after peripheral bypass operations were readmitted with their wound infections and hence were not captured.

Second, the NIS does not track outpatient visits, and so patients who were seen as outpatients would not have been captured as part of this sample.

Finally, some comorbidities, including renal failure and the presence of tissue loss, that have been associated with SSI after infrainguinal bypass were not included because the NIS is limited by the data available in the time periods reviewed. The urgency of operative procedures was not identifiable in the patient data set.

CONCLUSIONS

Implementation of SCIP guidelines has made no significant effect on the incidence of SSI in open vascular operations, including CEA or peripheral bypass. An increase in SSI rates in open, elective AAA repairs was observed in the post-SCIP era compared with the pre-SCIP era. These data suggest that the current approach to antibiotic administration in surgical patients may be inadequate for some vascular procedures and that a more patient-centric approach that takes into account factors, including the antibiotic resistance patterns of the hospital, glucose control, and weight, may be more suitable for patients undergoing open vascular surgery.

AUTHOR CONTRIBUTIONS

Conception and design: AD, SD, KB, GS, PR, BL, CL, CE
Analysis and interpretation: AD, SD, KB, GS, PR, BL, CL, CE
Data collection: AD, SD, CL
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REFERENCES

1. Weston A, Caldera K, Doron S. Surgical care improvement project in the value-based purchasing era: more harm than good? Clin Infect Dis 2013;56:424-7.
2. West J, Khan Y, Murray DM, Stevenson KB. Assessing specific secondary ICD-9-CM codes as potential predictors of surgical site infections. Am J Infect Control 2010;38:701-5.
3. Bratzler DW. Surgical care improvement project performance measures: good but not perfect. Clin Infect Dis 2013;56:428-9.
4. Edmiston CE, Spencer M, Lewis BD, Brown KR, Rossi PJ, Henen CR, et al. Reducing the risk of surgical site infections: did we really thinkSCIP was going to lead us to the promised land? Surg Infect (Larchmt) 2011;12:169-77.
5. Edmiston CE, Krepel C, Kelly H, Larson J, Andris D, Hennen C, et al. Perioperative antibiotic prophylaxis in the gastric bypass patient: do we achieve therapeutic levels? Surgery 2004;136:738-47.
6. Kaiser AB, Clayson KR, Mulherin JL Jr, Roach AC, Allen TR, Edwards WH, et al. Antibiotic prophylaxis in vascular surgery. Ann Surg 1978;188:283-9.
7. Patrick S, James C, Ali A, Lawson S, Mary E, Modak A. Vascular surgical antibiotic prophylaxis study (VSAPS). Vasc Endovasc Surg 2010;44:521-8.
8. Harbarth S, Fankhauser C, Schrenzel J, Christenson J, Gervaz P, Bandiera-Clerc C, et al. Universal screening for methicillin-resistant Staphylococcus aureus at hospital admission and nosocomial infection in surgical patients. JAMA 2008;299:1149-57.
9. Edmiston CE Jr, Krepel CJ, Edmiston SE, Spencer M, Lee C, Brown KR, et al. Empowering the surgical patient: a randomized, prospective analysis of an innovative strategy for improving patient compliance with preadmission showering protocol. J Am Coll Surg 2014;19:256-64.
10. Hawn MT, Richman JS, Vick CC, Deierhoi RJ, Graham LA, Henderson WG, et al. Timing of surgical antibiotic prophylaxis and the risk of surgical site infection. JAMA Surg 2013;148:649-57.
11. Pastor C, Artinyan A, Varma MG, Kim E, Gibbs L, Garcia-Aguilar J. An increase in compliance with the Surgical Care Improvement Project measures does not prevent surgical site infection in colorectal surgery. Dis Colon Rectum 2010;53:24-30.
12. Stulberg JJ, Delaney CP, Neuhauser DV, Aron DC, Fu P, Koroukian SM. Adherence to surgical care improvement project measures and the association with postoperative infections. JAMA 2010;303:2479-85.
13. Waits SA, Fritze D, Banerjee M, Zhang W, Kubus J, Englesbe MJ, et al. Developing an argument for bundled interventions to reduce surgical site infection in colorectal surgery. Surgery 2014;155:602-6.

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