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Surgical care improvement project and surgical site infections: can integration in the surgical safety checklist improve quality performance and clinical outcomes?¹

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Abstract

Introduction: The World Health Organization Surgical Safety Checklist (SSC) has been shown to decrease surgical site infections (SSI). The Surgical Care Improvement Project (SCIP) SSI reduction bundle (SCIP Inf) contains elements to improve SSI rates. We wanted to determine if integration of SCIP measures within our SSC would improve SCIP performance and patient outcomes for SSI.

Methods: An integrated SSC that included perioperative SCIP Inf measures (antibiotic selection, antibiotic timing, and temperature management) was implemented. We compared SCIP Inf compliance and patient outcomes for 1-y before and 1-y after SSC implementation. Outcomes included number of patients with initial post-anesthesia care unit temperature <98.6°F and SSI rates according to our National Surgical Quality Improvement Program data.

Results: Implementation of a SCIP integrated SSC resulted in a significant improvement in antibiotic infusion timing (92.7% [670/723] versus 95.4% [557/584]; P < 0.05), antibiotic selection (96.2% [707/735] versus 98.7% [584/592]; P < 0.01), and temperature management (93.8% [723/771] versus 97.7% [693/709]; P < 0.001). Furthermore, we found a significant reduction in number of patients with initial post-anesthesia care unit temperature <98.6°F from 9.7% (982/10,126) to 6.9% (671/9676) (P < 0.001). Institutional SSI rates decreased from 3.13% (104/3319) to 2.96% (107/3616), but was not significant (P = 0.72). SSI rates according to specialty service were similar for all groups except colorectal surgery (24.1% [19/79] versus 11.5% [12/104]; P < 0.05).

Conclusion: Implementation of an integrated SSC can improve compliance of SSI reduction strategies such as SCIP Inf performance and maintenance of normothermia. This did not,
1. Introduction

Surgical site infections (SSI) complicate up to 5% of all operations in the US and are the most frequent nosocomial infection among surgical patients [1]. With over 15 million surgical procedures performed in the US annually, an estimated 750,000 SSI will occur, resulting in additional direct and indirect cost to both the patient and the healthcare systems [1–4]. It has been reported that SSI can increase the post-operative length of stay by 7 to 10 days and hospital costs by 300% [5,6]. Furthermore, mortality rates can exceed 10% with certain infections [7]. Although effective prevention strategies exist, compliance is poor and outcomes are difficult to track [8,9]. Therefore, national programs for surgical quality performance and perioperative outcomes have been introduced as strategies to improve patient care and reduce complications [10–12].

The Surgical Care Improvement Project (SCIP) was developed by the Centers for Medicare and Medicaid Services to reduce SSI rates by 10% [10,12]. SCIP measures for SSI prevention (SCIP Inf) involve a multi-disciplinary approach including the proper timing of antibiotic infusion (SCIP Inf1), antibiotic selection (SCIP Inf2), appropriate discontinuation of prophylactic antibiotics (SCIP Inf3), appropriate hair removal method (SCIP Inf6), and maintenance of perioperative normothermia (SCIP Inf10), and euglycemia (SCIP Inf4). Compliance with SCIP quality performance measures is publicly reported and is tied to hospital reimbursement [11,13]. The National Surgical Quality Improvement Program (NSQIP) is a validated program used for improving surgical care through outcome measurement and direct provider feedback. Participation in NSQIP has shown to improve surgical outcomes in both low and high performing hospitals [14], and has been used to track outcomes of quality performance measures including SCIP [14–17]. While adherence to SCIP measures has controversial effects on patient outcomes [15,16,18–22], there is a growing incentive for compliance through pay-for-performance and pay-for-value initiatives [11,13,23].

Multi-disciplinary checklists including the World Health Organization (WHO) Surgical Safety Checklist (SSC) have been shown to decrease SSI, complications and mortality rates [24,25]. These improved patient outcomes are achieved, in part, through standardized steps during the checklist process that achieve error reduction and improve compliance with process-of-care measures. Haynes and colleagues showed that implementing a 19-item checklist in the perioperative period increased appropriate timing of antibiotic infusion from 56% to 83% with a significant reduction in SSI from 6.2% to 3.4% [24]. However, this study did not report other core SCIP Inf performance measures targeting SSI reduction. The purpose of this study was to determine if implementation of a standardized SSC (1) improved surgical team perceptions of SCIP Inf SSI reduction strategies, and (2) how implementation affected SCIP Inf quality performance measures and patient outcomes.

2. Methods

Scott and White Memorial Hospital is a 636 bed tertiary care hospital that actively participates in SCIP and NSQIP data bases and quality performance reporting. On September 1, 2010, we implemented a SSC with integration of SCIP Inf quality performance metrics in effort to improve patient safety and reduce complications, including SSI. The implementation process included a multidisciplinary team for development, validation through focused and limited SSC trial, surgical team training and education (including on-line CME activity with post-test), and monitoring and coaching of surgical teams post implementation [26]. SSI reduction strategies were focused on performance measures that could be verified through direct verbal communication during completion of the sections from our SSC (Table 1). These included (1) timing of antibiotic infusion (SCIP Inf1), (2) appropriate antibiotic selection (SCIP Inf2), and (3) appropriate perioperative temperature management (SCIP Inf10).

A survey of surgical team members (nursing, surgeon and anesthesia provider) perceptions regarding the SSC was distributed 1 month before (baseline) and 1 year after (follow-up) SSC implementation. This was an anonymous electronic survey carried out through survey monkey (www.surveymonkey.com), and participants were recruited through repeated e-mail invitations over a 1-month period. No incentives were provided for participation. Follow-up surveys were offered only to those who were invited at baseline. Survey data results reported in this study (three questions) are focused only on SSI reduction strategies integrated in the SSC that are outlined in Table 1, and are not detailed in a separate study of 33 survey questions, which focuses on surgical team communication, teamwork, operating room efficiency, and patient care [26].

| Table 1 – SCIP Inf performance measures verbally addressed in the Scott and White surgical safety checklist. |
|-----------------|-----------------|------------------|
| **SSC section** | **SCIP Inf** performance measures | **Verbal verification by surgical team** |
| Check in        | Inf-10 perioperative temperature management | Estimated time for procedure |
| Sign in         | Inf-10 perioperative temperature management | Risk of hypothermia (operation >1 h) |
| Time out        | Inf-2 antibiotic selection | Appropriate antibiotic ordered |
| Time out        | Inf-1 antibiotic timing | Antibiotic given within 60 min of incision (except vancomycin 120 min) |
The survey questions reported are included to show how implementation of a SSC affected surgery team perceptions of SCIP Inf performance metrics and how that related to actual performance and patient outcomes. The questions include (1) When preoperative antibiotics (excluding vancomycin) have been ordered, using incision time as a reference, to your knowledge, when are the antibiotics to be initiated? (2) Are you always aware in advance when the patient is at risk of hypothermia? and (3) After the surgical procedure has begun, how often do you adjust the temperature in the room or put on a patient warming device because of concern of patient hypothermia?

This study was performed in effort to determine effect and outcome of an institutional quality and safety improvement initiative. This study was submitted and approved as a retrospective review by the Scott and White Memorial Hospital Institutional Review Board. To determine the impact of our SSC on quality performance and patient outcomes we compared data for 1-y before (PRE) and 1-y after (POST) SSC implementation. Data for compliance of SCIP performance measures and NSQIP were collected prospectively and reported to their respective regulatory bodies. All SCIP measures designed to specifically reduce SSI (SCIP Inf) were evaluated, except for euglycemia in cardiac patients (SCIP Inf4) as this performance measure does not impact all patients reported in this study. The American College of Surgeons NSQIP database was used to evaluate our institutions surgical outcomes data for SSI and mortality. SSI included superficial, deep, and organ space as defined by NSQIP. Data reported include institutional composite, cardiac surgery, colorectal surgery, general surgery (non-colorectal non-vascular), gynecologic surgery, orthopedic surgery, thoracic surgery, and vascular surgery. These specialties were chosen as they correlate best with orthopedic surgery, thoracic surgery, and vascular surgery.

These specialties were chosen as they correlate best with orthopedic surgery, thoracic surgery, and vascular surgery. All patients evaluated and reported in this study had an operation with general anesthesia lasting >1 h with a documented first operating room (OR) temperature (after induction) and first post-anesthesia care unit (PACU) temperature (within 15 min of arrival). Patients who were hypothermic (temperature <96.8°F) at first PACU temperature were identified.

2.1. Statistical analysis

Data analysis was performed using GraphPad InStat (GraphPad Software, Inc, La Jolla, CA) statistics software. Categorical data are expressed as percentages and quantitative data are presented as mean ± SD. Statistical analysis was performed using t-test, χ² test, or Fisher’s exact test as appropriate. Statistical significance was defined as P value <0.05.

3. Results

3.1. Surgical team perceptions

Survey invitations were sent to a total of 824 surgical team members (469 baseline and 355 follow-up groups). Although the survey was related to all aspects of the SSC, the results reported in this study represent the surgical teams’ perceptions related to SCIP Inf performance measures only. The overall response rate was 53% with a total of 210 responses in the baseline group and 227 responses in the follow-up group. There were three questions specific to SCIP Inf performance measures, and these included timing of antibiotic infusion (SCIP Inf1) and perioperative temperature management (SCIP Inf10). For timing of antibiotic infusion (Fig.), 96% of the baseline and follow-up groups chose the correct answer that “except for vancomycin, antibiotics infusion should start ≤60 min before incision” (P = 0.96). Although perception of antibiotic infusion time did not change after implementation of our SSC, awareness and perception of perioperative temperature management was significantly improved in the follow-up group. First, Table 2 shows a significant improvement in the percentage of surgical team members that affirmatively responded that they were “aware in advance when the patient is at risk for hypothermia (case lasting >1 h)” (62.9% versus 77.1%; P < 0.001). Additionally, Table 3 shows there was also a significant increase in responses that >75% of the time the surgical team member adjusts the temperature in the operating room or puts on a patient warming device because of concern of patient hypothermia (17.2% versus 29.5%; P < 0.001).

3.2. Quality performance metrics and temperature management

Next, we determined whether implementation of our SSC improved perioperative SCIP Inf performance measures. Clearly shown in Table 4, the three SCIP Inf measures that are specifically addressed in our SSC (Inf1, Inf2, and Inf10) were significantly improved after its implementation (P < 0.05). The greatest improvement was in SCIP Inf10 (perioperative temperature management) that improved nearly 4% (93.8% to 97.7%; P < 0.001). SCIP Inf data not directly addressed in our SSC also improved, including Inf3, appropriate discontinuation of perioperative antibiotics (93.9% versus 96.7%; P < 0.05).

Fig. – Surgical team perception of antibiotic infusion time. Survey question: “When preoperative antibiotics (excluding vancomycin) have been ordered, using incision time as a reference, to your knowledge, when are the antibiotics to be initiated?” There was no difference in PRE versus POST group responses.
Although there was no significant improvement in SCIP Inf6 performance (appropriate method of hair removal), both PRE and POST groups achieved a high performance score of >99.5%.

As shown in Tables 2 and 3, the SSC improved perception and awareness of factors affecting perioperative temperature management, and this was associated with improvement in perioperative temperature management (SCIP Inf10) performance measure (Table 4). To determine clinical impact, we identified the first OR temperature measured and the first postoperative PACU temperature measured (Table 5). There were a total of 10,126 patients in the PRE group and 9676 patients in the POST group. Although the POST group started with a significantly lower first OR temperature \( (P < 0.001) \), the first PACU temperature in the POST group was significantly higher \( (P < 0.001) \), suggesting improved perioperative temperature management by the surgical team. Furthermore, there was a significant reduction in the number of patients who arrived in the PACU hypothermic with temperature <96.8°F versus 6.9%, \( P < 0.001 \).

### 3.3. NSQIP outcomes for SSI and mortality

To determine how our SSC associated improvement in SCIP Inf performance measures impacted patient outcomes, we determined SSI and mortality rates as measured through our institutional NSQIP data report (Table 6). Overall, our institutional SSI rates decreased from 3.13% to 2.96%, but the result was not significant \( (P = 0.72) \). The reported NSQIP SSI rates for our institution according to surgical specialty services were similar for all groups except colorectal surgery, which showed a significant decrease in SSI following SSC implementation (24.1% versus 11.5%; \( P < 0.05 \)). Although there was no difference in SSI rates for orthopedics, there was a substantial trend to decreased SSI rates (1.7% versus 0.7%; \( P = 0.06 \)). Finally, mortality rates were equivalent between groups (0.9% [30/3319] PRE versus 1.0% [36/3616]; \( P = 0.79 \)) with no difference seen within surgical specialty services.

### 4. Discussion

The main findings of our study is that a SSC with integrated SCIP Inf quality performance measures improves surgical team perceptions and compliance with these process-of-care measures on an institutional level. Improved perceptions of surgical team communication and intervention for hypothermia resulted in a decrease in number of patients with hypothermia upon arrival to the PACU. These findings did not result in overall improved SSI rates; however, a significant reduction in SSI was seen in colorectal surgery subspecialty group.

SSC have been shown to improve patient outcomes by reducing mortality and SSI rates \([24,25]\). These beneficial effects are a result of enhanced communication and consistent process-of-care performance \([25,27]\). Haynes and colleagues \([24]\) showed that use of a SSC was associated with an improvement in timing of antibiotic infusion (56.1% versus 82.6%) and resulted in a 42% reduction in overall SSI rates. In our study, we also found a small, but significant incremental improvement in performance of SCIP Inf1 antibiotic timing; however, we were already performing at a high level (92.7% to 95.4%). This may be why we did not see a significant improvement in overall institutional composite SSI rates (3.1% versus 3.0%). Bliss et al. \([28]\) reported similar results with antibiotic timing achieving 95.9% with no significant improvement in SSI (6.2% versus 5.5%; \( P = 0.85 \)); however, pre-SSC SCIP performance was not reported, SCIP Inf measures were not comprehensively evaluated, and hypothermia rates were not reported. Furthermore, the proportion of emergent cases was significantly lower in the SSC group which may account for any improved outcomes. In contrast, our SSC included SCIP Inf1 appropriate timing for antibiotic infusion, SCIP Inf2 antibiotic selection, and SCIP Inf10 perioperative temperature management, and each showed significant improvement. In fact, in all six SCIP Inf performance metrics, we achieved 95.4% to 99.6% compliance, indicating that incorporating specific SSI reduction strategies into a standardized SSC can be effective in improving process compliance and quality performance. As healthcare evolves into value-based purchasing, pay-for-performance, and fee-for-value type programs, checklists that integrate performance measures into process-of-care quality initiatives will be an effective tool to assure compliance and improve reimbursement.

The basis for individual SCIP Inf performance measures is compelling and has recently been reviewed \([12]\). Studies have
NSQIP data for surgical site infection rates for surgical patient temperature measurements

Table 4: SCIP performance measures for 1-y before (PRE) and 1-y after (POST) implementation of the Scott and White surgical safety checklist.

<table>
<thead>
<tr>
<th>SCIP Performance measures</th>
<th>PRE</th>
<th>POST</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inf-1 Antibiotic timing</td>
<td>670/723 (92.7%)</td>
<td>557/584 (95.4%)</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Inf-2 Antibiotic selection</td>
<td>707/735 (96.2%)</td>
<td>584/592 (98.7%)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Inf-3 Antibiotic end</td>
<td>636/677 (93.9%)</td>
<td>528/546 (96.7%)</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Inf-6 Hair removal</td>
<td>1039/1044 (99.5%)</td>
<td>914/918 (99.6%)</td>
<td>0.99</td>
</tr>
<tr>
<td>Inf-10 Perioperative temp</td>
<td>723/771 (93.8%)</td>
<td>693/709 (97.7%)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

Table 5: Surgical patient temperature measurements and rate of hypothermia PRE and POST implementation of the Scott and White surgical safety checklist.

<table>
<thead>
<tr>
<th>Temperature results</th>
<th>PRE</th>
<th>POST</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total patients to PACU</td>
<td>n = 10,126</td>
<td>n = 9,676</td>
<td></td>
</tr>
<tr>
<td>First OR temperature</td>
<td>97.0 ± 1.4°F</td>
<td>96.9 ± 1.2°F</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>First PACU temperature</td>
<td>97.7 ± 0.9°F</td>
<td>97.8 ± 0.8°F</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Temperature change</td>
<td>0.7 ± 1.4°F</td>
<td>0.9 ± 1.2°F</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>PACU temperature</td>
<td>982 (9.7%)</td>
<td>671 (6.9%)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

NSQIP is a validated national database to track and improve surgical outcomes and has been effectively used to assess impact of SCIP and SSC implementation on patient outcomes [14,28]. In our study, unadjusted SSI rates from NSQIP were used as the time frame for PRE and POST groups did not correspond with standard semiannual reporting. Although composite SSI rates remained unchanged, there was a greater than 50% reduction in SSI rates in the colorectal surgery group (24.1% versus 11.5%; P < 0.05). To ensure our findings were not related to disproportionate risk factors, we verified our findings with risk adjusted SSI data for colorectal surgery according to the semiannual report. The dramatic improvement in observed/expected ratio from 1.6 (July 2009–June 2010) to 1.1 (January 2011–December 2011) indicates that the improvements found in our study using unadjusted data is meaningful, and we must focus on specialty specific needs and variables.

Colorectal operations have higher rates of SSI compared with other surgical subspecialties, with reported rates as high as 26% [31], and provides the opportunity for optimization of SSI reduction bundles to improve outcomes. SSI reduction bundles including SCIP Inf performance measures, wound management in patients with body mass index >25, and change in operative decision-making has been shown to reduce SSI by up to 40% following colorectal operations [32,33]. We found similar results with over 50% reduction in SSI following colorectal surgery with implementation of a SCIP Inf integrated SSC. During the study period, we have not made significant changes to our practice, including antibiotic selection or use of preoperative bowel preparation. Normothermia has been associated with significant reduction in SSI rates in colorectal surgery, and is the basis for SCIP Inf10 recommendation [12,34]. In our study, incorporating communication of patient risk for hypothermia in the SSC
improved surgical team awareness, perceived patient care action, and was associated with a 30% reduction in PACU hypothermia rates. Although we do not have specific data on maintenance of hypothermia in colorectal patients specifically, our data includes all patients recovered in the PACU whose operation was over 1 h. To our knowledge, all colorectal cases tracked by NSQIP take greater than 1 h to complete, and should be comprehensively included in our data.

Given the study design and quality improvement focus, there are limitations to our study that must be discussed. First, SCIP and NSQIP do not report on all cases, but these programs are a validated snapshot of surgical patient outcomes on an institutional and surgical specialty level [12,14–16]. It would be of benefit to directly link SCIP to individual patient outcome performance on NSQIP, but this is beyond the scope of our study. Second, we actively educate surgical team members and residents on SCIP measures, definitions, and identified SCIP failures. This, however, is a part of our continued surgical quality improvement initiative and is designed to maintain our SCIP awareness and performance. Finally, our study was a single institution experience with SSC implementation and impact on SCIP Inf quality measures and patient outcomes. Effective SSC use and compliance is dependent on multiple factors, including physician culture. It would be important to determine these barriers and how they might affect the success of SSC implementation on quality performance and outcomes.

Implementation of our quality integrated SCC improved awareness and action of surgical teams to SSI reduction strategies (SCIP Inf bundle). The use of standardized communication tools such as checklists ensure a high standard of quality of care and will be a valuable tool to effectively participate in pay-for-value and value-based purchasing programs. Achieving a high level of quality performance in SCIP Inf bundle improved SSI rates in colorectal surgery; however, this did not correlate with institutional or non-colorectal surgical subspecialties. Further investigation is required to determine other factors that may influence SSI across varied surgical specialties. Our data suggest that there is a plateau performance level where institutions will start to see diminishing returns for resources utilized for SCIP. Quality improvement assessment and program sustainability requires that quality performance measures be directly tied to improved patient outcomes to ensure an improvement in delivery of care.

REFERENCES

[1] Consensus paper on the surveillance of surgical wound infections. The Society for Hospital Epidemiology of America; the Association for Practitioners in Infection Control; the Centers for Disease Control; the Surgical Infection Society. Infect Control Hosp Epidemiol 1992;13:599.


