A Protocol-Driven Reduction in Surgical Site Infections After Colon Surgery

Carolina Martinez, MD, Pamela Omesiete, MD, Viraj Pandit, MD, Eli Thompson, MS, Meleesa Nocera, MS, Taylor Riall, MD, Marlon Guerrero, MD, and Valentine Nfonsam, MD*

Department of Surgery, College of Medicine, University of Arizona, Tuscon, Arizona

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**Abstract**

Background: Surgical site infection (SSI) is an established quality indicator and predictor for adverse patient outcomes. Multiple strategies have been established to reduce SSI; however, optimum protocol remains unclear. The aim of the study was to assess the impact of established protocol on SSI after colon surgery.

Methods: We established a colon SSI bundle in 2017, which includes a chlorhexidine pre-scrub followed by chloraPrep, betadine wound wash, antibiotic infused irrigation, use of closure tray, and incision coverage with silver impregnated dressing. Retrospective analysis of a 2-y (2016-2017) prospectively collected before and after analysis of all patients undergoing elective colon surgery was performed. Patients were divided into two groups: preprotocol (PP: year 2016) and postprotocol (PoP: year 2017). Patients in the two groups were matched using propensity score matching for age, gender, comorbidities, Anesthesiology Severity Score, indication of procedure, and procedure type. Outcome measures were SSI, hospital length of stay, and readmission rate.

Results: A total of 328 patients were analyzed, and after propensity matching, 94 patients (PP:47 and PoP:47) were included. The mean age was 63.7 ± 16.4 y, 43.6% male, and 44.6% of procedures were performed laparoscopically. There was no difference in demographics, comorbidities, and procedure details between two groups. PoP patients had significantly lower superficial (odds ratio: 0.91 [0.74-0.98]; P = 0.045) and deep SSI (odds ratio:0.97 [0.65-0.99]; P = 0.048) than PP patients. PoP patient had shorter length of stay (P = 0.049) and trend toward lower readmission rate (P = 0.098) compared with PP patients and an 85% reduction in the Centers for Medicare and Medicaid Services standardized infection rate.


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Introduction

Surgical site infections (SSIs) are one of the most common and costly health care—associated morbidities. The financial burden of SSI within the United States approximates $3.5 billion to $10 billion annually. SSI impedes patient recovery by causing most unplanned patient readmissions and reoperations.1,2 The SSI rates for colorectal surgeries are associated with patient comorbidities, acuity at presentation, and type of surgery performed. The higher bacterial load in the colon increases the risk of SSI in elective colon surgery. In a study sampling surgical incisions in open colon surgery, approximately 48% of the wounds sampled were contaminated, and 10% developed a clinically relevant wound infection postoperatively.3 This demonstrates the importance of established protocols to reduce SSIs in this particular patient population.

SSI causes financial strain but more importantly causes physical strain by hindering the patient’s overall quality of life. To combat the high rates of SSI and reduce the physiological responses to major surgery, different protocols have been designed and implemented. In the 1990s, the enhanced recovery after surgery (ERAS) protocol was introduced for colorectal surgery.4,5 This protocol contains evidence-based modern care changes from overnight fasting to carbohydrate drinks 2 h before surgery, minimally invasive approaches, management of intravenous (IV) fluid, and early mobilization.6 ERAS protocol implementation led to the improvement of patient care by decreasing length of stay and lowering SSI rate.

Despite the wide adoption of the ERAS protocol across various institutions, SSI continues to be a problem. The purpose of our study was to determine if a directed colon SSI bundle adopted in 2017 facilitates reduced SSI in patients undergoing colon surgery.

Methods

This is a single-surgeon, single-center study conducted at a tertiary university medical center. We reviewed the medical records of patients undergoing elective colon surgery over a 2-year period (January 2016 to December 2017). The SSI bundle was implemented in January of 2017. A retrospective analysis was performed on data collected prospectively before and after the protocol was implemented. The SSI bundle protocol was implemented by gynecological oncology, trauma surgery, general surgery, and colorectal surgery. For this study, only elective colon resections, performed by a single surgeon, were analyzed to further evaluate the effects of bundle modifications on SSI rates. During this study time, the ERAS protocol was not in place at the institution. This study was approved by the Institutional Review Board at the University of Arizona, and an informed consent was obtained from patients enrolled in the study.

Study protocol

The colon SSI bundle protocol implemented in 2017 included a chlorhexidine prescrub, chloraprep scrub, antibiotic-infused irrigation, betadine wound wash, incision coverage with Mepilex AG silver impregnated dressing, strict glucose control, and 24-h perioperative antibiotics. None of the patients received mechanical bowel prep but received oral antibiotic with neomycin and Flagyl preoperatively. In addition, a prophylactic dose of IV cefoxitin was administered within an hour of incision time and every 8 h postoperatively for 24 h. We included the standard use of intraoperative redosing when it was indicated for prolonged procedure times. A closure tray was used, and all surgeons were required to rescrub and change their gowns and gloves.

Inclusion and exclusion

All patients aged >18 y who underwent elective colon resection for cancer were included. Patients who had emergent colorectal procedures or diagnosed with inflammatory bowel disease or diverticulitis were excluded from the study.

Outcome measure

The patients were divided into two groups: preprotocol (PP: year 2016) and postprotocol (PoP: year 2017). The patients were matched for age, gender, ASA score, indication of procedure, and procedure type using 1:1 propensity score matching. The patients were also matched for comorbidities including diabetes mellitus, hypertension, hyperlipidemia, coronary artery disease, and chronic kidney disease. The primary outcome measured was deep and superficial SSI rate. Deep SSIs were defined as those beneath the fascia, and superficial SSIs were defined as those above the fascia. Secondary outcomes measured were length of stay, hospital readmission, and other complications.

Statistical analysis

Data are reported as mean ± standard deviation for continuous descriptive variables, median (range) for ordinal descriptive variables, and proportions for categorical variables. We performed Mann–Whitney U test and Student t-test to explore for differences in the two groups (PP and PoP) for continuous variables. We used chi-square test to identify differences in outcomes between the two groups for categorical variables. For our study, we considered P value < 0.05 as statistically significant. Multivariate regression analysis was performed to assess for factors associated with the development of complications. All statistical analyses were performed using Statistical Package for Social Sciences (SPSS, Version 20; SPSS, Inc, Chicago, IL).

Results

A total of 590 patients were identified, of which 348 had undergone colorectal resection. Of these, 20 patients were excluded because of missing data. There were 178 patients identified in the PP and 150 patients in the PoP group. Overall, 94 patients were included in the study after propensity matching. Forty-seven patients had their surgery PP, whereas
47 patients had their surgery PoP. A flowchart of the study detail is shown in Figure. Of the 94 patients included in the propensity score matching, 43.6% were male, and the mean age was $63.7 \pm 16.4$ y. The demographics and comorbidities did not differ between PP and PoP groups as shown in Table 1.

Majority of the patients in both groups had open surgery (PP: 59.5% and PoP: 57.4%) as demonstrated in Table 2. A small percentage of the patients in both groups received neo-adjuvant therapy (PP: 38.3% and PoP: 34%) and steroids (PP: 17% and PoP: 12.7%). Both groups were similar for having a diverting ostomy (19.1% PP versus 23.4% PoP; $P = 0.61$) and end ostomy (27.6% PP and 34% PoP; $P = 0.51$).

Table 3 shows that patients in the PoP group had lower complications rates (PP: 29.8% versus PoP: 12.7%; $P = 0.04$). In addition, there was a significant decrease in the incidence of superficial (4.2% PoP versus 17% PP; $P = 0.04$) and deep SSI (2.1% PoP versus 10.6% PP; $P = 0.04$) in the PoP group when compared with patients in the PP group. In terms of hospital length of stay, patients in the PoP group spent 1 d less in the hospital when compared with the PP group (PoP: 3 [2-5] d versus PP: 4 [2-7] d versus $P = 0.04$). There was no statistically significant difference in readmission rates between the two groups (PP: 21.2% versus PoP: 12.7%; $P = 0.1$). The study

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**Table 1 – Demographics.**

<table>
<thead>
<tr>
<th>Variable</th>
<th>PP (n = 47)</th>
<th>PoP (n = 47)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demographics</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age, y, mean ± standard deviation</td>
<td>63.7 ± 14.2</td>
<td>62.5 ± 13.5</td>
<td>0.67</td>
</tr>
<tr>
<td>Male, n (%)</td>
<td>21 (44.6)</td>
<td>27 (53.2)</td>
<td>0.41</td>
</tr>
<tr>
<td>Caucasian, n (%)</td>
<td>29 (61)</td>
<td>25 (59.5)</td>
<td>0.88</td>
</tr>
<tr>
<td>Hispanic, n (%)</td>
<td>19 (40.4)</td>
<td>23 (48.9)</td>
<td>0.49</td>
</tr>
<tr>
<td>Comorbidities</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ASA, median (IQR)</td>
<td>3 (2-3)</td>
<td>3 (2-3)</td>
<td>0.51</td>
</tr>
<tr>
<td>BMI, median (IQR)</td>
<td>28 (22-33)</td>
<td>27 (23-32)</td>
<td>0.42</td>
</tr>
<tr>
<td>DM, n (%)</td>
<td>12 (25.5)</td>
<td>16 (34)</td>
<td>0.37</td>
</tr>
<tr>
<td>HTN, n (%)</td>
<td>19 (40.4)</td>
<td>22 (46.8)</td>
<td>0.53</td>
</tr>
<tr>
<td>HLD, n (%)</td>
<td>18 (38.3)</td>
<td>13 (27.6)</td>
<td>0.27</td>
</tr>
<tr>
<td>CAD, n (%)</td>
<td>8 (21.2)</td>
<td>6 (23.4)</td>
<td>0.79</td>
</tr>
<tr>
<td>CKD, n (%)</td>
<td>7 (14.9)</td>
<td>11 (23.4)</td>
<td>0.29</td>
</tr>
</tbody>
</table>

ASA = Anesthesiology Severity Score; BMI = body mass index; CAD = coronary artery disease; CKD = chronic kidney disease; DM = diabetes mellitus; HLD = hyperlipidemia; HTN = hypertension; IQR = interquartile range.
shows that patients who received the colon SSI bundle had lower measurements in both the primary and secondary outcomes.

On regression analysis, protocol implementation was independently associated with lower superficial and deep SSI rate. Table 4 demonstrates details of the regression analysis.

### Discussion

Poeran et al. in their recent study, which looked at more than 90,000 colectomies performed in the United States, concluded that only 51.6% of patients received antibiotics on the day of surgery. Another study performed by Markell et al., looking at surgeons in the American Society for Colon and Rectal Surgeons, noted that only 36% of responders used prophylactic oral antibiotics in addition to perioperative IV antibiotics.

These findings clearly demonstrate a disconnect in clinical practice among US surgeons in colorectal surgery. It is well documented that the colorectal surgical subspecialty experiences a much higher rate of SSIs compared with other surgical subspecialties and attempts atSSI reduction continues to be a strong topic of discussion. This long-standing issue poses a significant problem that impacts both patients and the health care system along with the utilization of resources. Various attempts at reducing SSIs have been proposed, including oral and IV antibiotics in the perioperative period as well as mechanical bowel preparation before surgery. Nonetheless, single-mode approach is clearly insufficient in achieving acceptable reductions in SSI. Since the development of the surgical care bundles, it has been demonstrated that multimodal approach is necessary to bring about a continued reduction in SSIs.

The effect of bundles on infection control has been clearly demonstrated in large, multicenter studies. A 66% reduction in ventilator-associated infections was seen in US intensive care units after the implementation of a multifaceted intervention to improve compliance with five evidence-based recommendations for mechanically ventilated patients. A similar reduction in catheter-associated infections was seen after a widely adopted bundle was used. Our study suggests that by establishing a colon SSI bundle, we were able to significantly decrease SSIs in colorectal surgery and therefore improve patient outcomes. After the implementation of our bundle, we noted a decrease in superficial SSI from 17% to 4.2% as well as a decrease in deep SSI from 10.6% to 2.1%. This is comparable to a prospective study by Crolla et al., which demonstrated a 36% reduction in SSI after the implementation of a colorectal bundle. They also looked at bundle use compliance and found an increased compliance rate as the bundle was implemented. A systemic review specifically looking at the effects of bundles on SSI also found a significant reduction in SSI. This systematic review included 16 studies in the analysis with a total pool sample of 8515 patients and found that the rate of SSI in the bundle group was 7.0% compared with 15.1% in the nonbundle group. The bundles in most of these studies included antibiotic administration, hair removal techniques, glycemic control, and normothermia.

Bundles not only reduce SSIs but also reduce complications in patients. Overall complications, including urinary tract infections, pneumonias, and pulmonary embolisms, were reduced in our bundle care group. This reduction was noted to be from 29.7% to 12.7% in the PoP group. Again, this is consistent with other studies aimed at implementing bundles in colorectal surgery.

Some studies have shown that bowel preparation bundles do not have a significant impact on the occurrence of SSIs when compared with no bowel preparation. However, in our study, we found that the colon SSI bundle given to the PoP patients did significantly reduce the percentage of SSI following elective colon surgery. The interventions used in previous SSI bundles have varied, and this may have resulted in their ineffectiveness. Most SSI bundles consist of standard steps such as hair removal, antimicrobial therapy, and glycemic control. Although important, these interventions may not be enough to reduce the risk of infection. The specific steps used in the colon SSI bundle that we established and the

### Table 2 – Surgery details.

<table>
<thead>
<tr>
<th>Variable</th>
<th>PP (n = 47)</th>
<th>PoP (n = 47)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colon cancer, n (%)</td>
<td>23 (48.9)</td>
<td>22 (46.8)</td>
<td>0.83</td>
</tr>
<tr>
<td>Diverticulitis, n (%)</td>
<td>13 (27.6)</td>
<td>12 (25.5)</td>
<td>0.81</td>
</tr>
<tr>
<td>Inflammatory bowel disease, n (%)</td>
<td>11 (23.4)</td>
<td>13 (27.6)</td>
<td>0.64</td>
</tr>
</tbody>
</table>

### Table 3 – Outcomes.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Complications, n (%)</th>
<th>Superficial SSI, n (%)</th>
<th>Deep SSI, n (%)</th>
<th>Anastomotic leak, n (%)</th>
<th>Hospital stay, d, median (IQR)</th>
<th>Readmission, n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>14 (29.8)</td>
<td>8 (17)</td>
<td>6 (12.7)</td>
<td>4 (8.5)</td>
<td>4 (2–7)</td>
<td>10 (21.2)</td>
</tr>
</tbody>
</table>

IQR = interquartile range.

### Table 4 – Outcomes.

<table>
<thead>
<tr>
<th>Variable</th>
<th>PoP</th>
<th>OR</th>
<th>95% CI</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Superficial SSI, n (%)</td>
<td>0.91</td>
<td>0.74-0.98</td>
<td>0.045</td>
<td></td>
</tr>
<tr>
<td>Deep SSI, n (%)</td>
<td>0.97</td>
<td>0.65-0.99</td>
<td>0.048</td>
<td></td>
</tr>
</tbody>
</table>

CI = confidence interval; OR = odds ratio.
consistency of their implementation could explain the reduction in SSI in this study.

One of the most effective indicators for patient recovery is the length of hospital stay (LOS). SSI extend the LOS on average 9.7 d per patient signifying a difficult recovery process. A similar study displayed results demonstrating a decreased LOS of at least 1 d because of an implementation of a multidisciplinary patient care bundle designed to reduce SSI. Our findings parallel these results yielding a decreased length from 4 d PP to 3 d PoP. Without SSIs, patients do not require additional wound treatment or additional time to recover, which allows a more expedited discharge date. Increased readmission rates are another useful indicator for negative patient event. Our data present trends, indicating an overall 8.5% decrease in readmission rates after the implementation of our bundle. This trend is potentially explained by the reduction of SSIs that lead to less readmissions. More than 90,000 readmissions are attributed to SSI in the United States. With less cases of SSI, readmission rates drop, indicating improved patient recovery.

The limitations within this study include the small sample size of patients included after propensity matching. The smaller sample size restricts the generalizability and accuracy of our results. As a single-center study, our data are limited. By expanding the number of patients both PP and PoP, we may see a more accurate representation on how the colon SSI bundle reduces SSI. However, despite these limitations, we feel stern that our data are cleaner and well matched, and the results are more valid and conclusive. The second limitation of this study is several known risk factors for SSI such as perioperative hypoglycemia and hypothermia were not recorded. However, because of the number of patients included in the study, these factors are unlikely to reflect in the results. A future study in which the limitations are removed may yield accurate results likely to demonstrate the direct effects of the colon SSI bundle.

Our bundle does not require expensive or complicated interventions. The Institute for Healthcare Improvement emphasizes that the successful implementation of a bundle depends both on the systematic and consistent application of all elements within a bundle. The simplicity of our bundle allows for easy implementation, increased compliance, and easy reproducibility. A zero-tolerance policy is required, and all bundle components should be used in all patients to ensure improved outcomes.

Conclusion

In conclusion, our study supports the use of bundles for reduction in SSIs in patients undergoing elective colorectal surgery for colon cancer. Our study clearly demonstrates that implementation of a simple SSI bundle in elective colorectal cases, coupled with strict compliance, will lead to a significant decrease in SSI, overall complications, and LOS.

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Disclosure

The authors report no proprietary or commercial interest in any product mentioned or concept discussed in this article.

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