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# Intrawound vancomycin powder decreases staphylococcal surgical site infections following posterior instrumented spinal arthrodesis

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## Abstract

**Study Design—**A retrospective historical cohort design.

**Objective—**To determine what effect the addition of intrawound vancomycin powder to the prophylactic regimen of posterior instrumented spinal arthrodesis procedures has had on acute surgical site infections.

**Summary of Background Data—**Surgical site infections (SSI) are known complications in instrumented spinal arthrodesis procedures, and are predominately caused by *Staphylococcus aureus*. Recent reports have suggested that placing vancomycin powder into the surgical wound prior to closure prevents surgical site infections in spinal surgery. Risk factors for SSIs in the setting of intrawound vancomycin powder use have not been previously reported on.

**Methods—**Surgical site infection rates following 342 posterior instrumented spinal arthrodeses (Oct. 2008 to Sept. 2011) in which intrawound vancomycin powder was used in addition to the standard antimicrobial prophylaxis (Vanco cohort) were compared to 341 posterior instrumented spinal arthrodeses (Apr. 2005 to Oct. 2008) in which no vancomyin powder was added (Non-Vanco cohort). Both two sample t-test and Chi-square test (Fisher's where appropriate) were used for group comparisons. A sub-analysis of the Vanco cohort was undertaken to identify risk factors for SSIs despite intrawound vancomycin use.

**Results—**There was a significant reduction in the number of acute staphylococcal SSIs in the Vanco cohort (1.1%) compared to the Non-Vanco cohort (3.8%) (p=0.029). Deep staphylococcal infections decreased to 0 compared to 7 in the Non-Vanco cohort (2.1%) (p=0.008). Deep MRSA infections decreased to 0 compared to 5 in the Non-Vanco cohort (1.5%) (p=0.031). Sub-analysis of the Vanco cohort identified that being discharged to an inpatient rehabilitation or skilled nursing facility was associated with developing a SSI.

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IRB Approval:
This study was approved by the University of Kansas Medical Center.

Conflict of Interest:
The authors have no conflicts of interest related to the content of this manuscript.

**Conclusions—**Intrawound vancomycin powder use has decreased the rate of acute staphylococcal SSIs in our posterior instrumented spine arthrodesis surgeries. Patients who are discharged to skilled nursing or rehabilitation facilities are at increased risk for developing SSIs despite intrawound vancomycin use.

### Keywords

vancomycin; surgical site infection; staphylococcus aureus; SSI prophylaxis; posterior instrumented spinal arthrodesis

## Introduction

Surgical site infections (SSIs) are a common concern among the surgical specialties. They dramatically increase the cost associated with surgery and negatively affect patient outcomes. Nationally the total annual cost of SSIs is estimated to be between $1 billion and $10 billion[1]. The most common cause of an orthopedic SSI is *Staphylococcus aureus* followed by coagulase-negative staphylococci[1,2].

Risk factor reduction protocols and proper antimicrobial prophylaxis (AMP) therapy are generally part of the surgical standard of care at most facilities. However, maintaining these preventive measures has not resulted in a reduction in SSI incidence in the past decade, and refinement of these techniques is unlikely to cause a significant decrease[3]. Finding new antimicrobial prophylactic treatments for SSIs is now imperative for controlling infections postoperatively and for controlling health care costs. Routine use of intravenous vancomycin for SSI prophylaxis is not recommended[4,5]. It has not been shown to be any more effective than using intravenous cephalosporins (e.g. cefazolin) in preventing SSIs[5,6], nor has it been shown to be any more effective in preventing methicillin-resistant *S. aureus* (MRSA) SSIs[7].

Recently, administering vancomycin powder locally, directly to the wound, has been shown to decrease SSI rates following spinal surgery procedures[8–10]. These studies did not investigate risk factors for surgical site infections in the setting of intrawound vancomycin use. The purpose of this study was to determine if the use of intrawound vancomycin powder has decreased the rate of acute surgical site infections due to staphylococci in posterior instrumented spinal arthrodesis surgeries at our institution, and to identify risk factors for surgical site infections in the setting of intrawound vancomycin powder use.

## Materials and Methods

This study used a historical cohort design and was approved by the Human Subjects Committee at the University of Kansas Medical Center. A single surgeon performed all procedures. Prior to October of 2008 all patients undergoing posterior instrumented spinal arthrodesis received standard AMP. Beginning in October of 2008 all patients undergoing posterior instrumented spinal arthrodesis received between 0.5 g to 2 g of vancomycin powder applied directly to the wound just prior to closure, in addition to standard AMP. Standard AMP for spinal surgery included 20 mg/kg body weight of Ancef given intravenously within one hour prior to incision and with repeat dosing every four hours during surgery. Post-operatively, patients were given 1 g of Ancef intravenously every 8

hours for 24 hours. If the patient was a known MRSA carrier or was allergic to Ancef, 1 g of vancomycin given intravenously could be substituted, as previously recommended[3,5]. Additionally, all patients were given chlorhexidine scrub brushes and instructed to wash with them the night before and the morning of surgery. The operative location was prepped with alcohol, betadine scrub and betadine paint prior to incision in all patients. Either 0.5, 1.0 or 2.0 grams of vancomycin were used on each patient. In small patients (children and small adults) with a single level arthrodesis, the 0.5 g dose was chosen. In larger adults (70+ kg) with a one or two level arthrodesis, the 1.0 g dose was chosen. For arthrodeses more than two levels, the 2.0 g dose was chosen.

There were 690 consecutive spinal surgeries performed between October 2008 and September 2011. Of these 690 surgeries, 371 of them were posterior instrumented spinal arthrodeses, and these became our Vanco cohort. To identify our Non-Vanco control cohort, who did not receive intrawound vancomycin powder, we identified 371 consecutive posterior instrumented arthrodesis surgeries immediately prior to October 2008. In order to identify these 371 surgeries, we examined 765 consecutive spinal surgeries from April 2005 to October of 2008. To be included in our analysis patients had to have a minimum of 90 days of follow-up or a SSI occurring within 90 days of operation.

Demographic and operative data were gathered for all patients. Acute SSI was our primary outcome. We defined an SSI as those infections occurring within 90 days following the operation, requiring an additional operation (i.e. an irrigation and debridement) and having positive wound cultures. Infections were further subdivided into superficial (occurring above the lumbosacral fascia) or deep (beneath the lumbosacral fascia) based on the wound culture reports and operative reports. Descriptive statistics were used to summarize demographic, hospitalization, and operative characteristics between the Vanco and Non-Vanco cohorts as well as their infection status. The chi-square and independent sample t-test were used when appropriate for group comparisons. Data with missing values were excluded from the analysis.

To identify risk factors for surgical site infections in the setting of intrawound vancomycin use, a sub-analysis of the Vanco cohort was performed. Demographic and operative risk factors were compared between those patients having a SSI and those not having a SSI using the independent sample t-test and chi-square test. All data analysis was performed with SAS 9.3 (SAS Institute Inc., Cary, NC, USA).

## Results

We found 92% of the 371 cases in both study groups had 90 days or greater follow-up (N=342 for Vanco cohort and N=341 for Non-Vanco cohort). The demographic and operative data are listed in Table 1 and Table 2 respectively. The Vanco cohort was significantly older with a mean age of 55.3 years compared to the Non-Vanco cohort with a mean age of 49.1 years ($p<0.0001$). The Vanco cohort had a higher number of patients with hypertension at 56.7% of patients compared to 41.9% in the Non-Vanco cohort ($p<0.0001$). Largely the demographic and hospital stay data were similar across the two study groups.

More patients in the Vanco cohort had had a previous surgery at the spinal level treated in this study (50.0%) compared to the Non-Vanco cohort (39.8%), and this was statistically significant (p=0.007). Almost all of the patients in the Vanco cohort had hair removed with electric clippers (98.8%) with the remainder having no hair removal (1.2%) and none of the patients had hair removed with a razor. However, the Non-Vanco cohort had 1.5% with razor hair removal, only 92.5% with electric clippers and the remaining 6.0% had no hair removal. Differences among hair removal types were statistically significant (p<0.001).

The infection rates are shown in Table 3. There was a statistically significant decrease in staphylococcal infections in the Vanco cohort (1.1%) compared to the Non-Vanco cohort (3.8%) (p= 0.029). There were 0 deep staphylococcal infections in the Vanco cohort, whereas there were 7 in the Non-Vanco cohort (2.1%), and this difference was statistically significant (p=0.008). There were 0 deep MRSA infections in the Vanco cohort compared to the Non-Vanco cohort, which had 5 (1.5%) (p=0.031). There were 5 (1.5%) non-staphylococcal infections in each cohort (p=1.00). There were no adverse events associated with vancomycin powder use.

When comparing those patients that had an infection (N=7) to those patients that did not have an infection (N=335) in the Vanco cohort (Tables 4 and 5), we found a higher percentage of patients developing infections being discharged to inpatient rehabilitation or skilled nursing facilities rather being discharged home. Amongst those without SSIs, 83.9% were discharged home, while 5.4% went to skilled nursing and 10.8% went to inpatient rehabilitation. Amongst those developing SSIs 57.1% were discharged home, while 14.3% went to inpatient rehabilitation and 28.6% went to skilled nursing facilities (p=0.031).

## Discussion

The purpose of this study was to determine if the addition of intrawound vancomycin powder to the operative AMP regimen has decreased the rate of acute SSIs due to staphylococci in our Vanco cohort compared to a Non-Vanco historical control cohort. Intrawound vancomycin powder use has decreased the total number of acute staphylococcal SSIs from (13) to (4) (p=0.029) and reduced the deep staphyloccocal rate from 7 to 0 (p=0.008). There was also a significant decrease in deep MRSA infections from 5 (1.5%) to 0 with the addition of vancomycin powder (p=0.031). We did not see a change in the rate of non-staphylococcal infections between the two groups. Each group had 5 such infections (p=1.00).

Sweet et al have carried out the most definitive work to date on the effectiveness of intrawound vancomycin powder use to prevent SSIs in spine surgery[8]. In their prospective cohort study, 911 of 1,732 consecutive posterior instrumented thoracic and lumbar spinal arthrodeses from 2000 to 2006 had 2 g of intrawound vancomycin powder added as prophylaxis[8]. They had a deep infection rate of 2.6% in the 821 patients not receiving the vancomycin powder compared to 0.2% in the group receiving the vancomycin powder[8]. The reduction was statistically significant (p<0.0001). Similar to our study they found 71% of their infections in the non-vancomycin group to be staphylococci compared to no deep staphylococci infections in the vancomycin group[8]. O'Neill et al published a study on the

effectiveness of intrawound vancomycin powder to prevent infections following spinal surgery in a trauma population[9]. They compared 54 control patients not receiving the vancomycin powder to 56 patients receiving the powder over a two-year period[9]. They found seven infections (13%) in the group not receiving vancomycin and no infections in the vancomycin group (p=0.02)[9]. A case series by Molinari et al similarly associates the use of vancomycin powder with lowered SSI rates in spinal surgery[10].

Sweet et al have shown that vancomycin powder is not readily absorbed into the systemic circulation, but instead stays in the wound and acts locally to prevent infection[8]. We believe this is the mechanism for the drastic decrease in deep infections we observed in this study. With the results of our study and these previous studies it appears that more and more spine surgeons will begin using vancomycin powder. We anticipate this will decrease staphyloccocus infections. However, non-staphylococcal SSIs (superficial and deep) will continue to occur and it will be important to identify risk factors for SSI in the setting of intrawound vancomycin powder use as even one infection can be catastrophic for patient morbidity and healthcare costs. Our sub-analysis of the Vanco cohort identified that being discharged to inpatient rehabilitation or skilled nursing facilities was associated with developing a SSI. This finding has not been previously reported.

Strengths of this study are that it includes a variety of surgical indications at all spinal levels, which may make the outcomes generalizable to a general spine surgeon's practice. This is also the first study to investigate risk factors for SSIs despite adding vancomycin powder to the surgical wound prior to closure. The Vanco cohort did have a significantly greater number of revision surgeries (50%) compared to the Non-Vanco cohort (39.8%) (p=0.007), which could reflect a bias, but these revision surgeries are typically longer, more technically challenging cases which would likely increase the risk of developing a SSI. This could be a factor in our inability to show statistical significance in reducing the overall infection rate in the treatment group.

This study is limited in that it was retrospective and was limited to data previously recorded in medical records. There was a statistically significant difference in the type of hair removal performed prior to surgery between the Vanco and Non-Vanco cohorts. Shaving with a razor has previously been identified as a risk factor for infection and this is a possible confounder for our findings[4]. However, only one of the patients in the Non-Vanco cohort that developed a SSI had their hair removed with a razor. This would not explain the drastic decrease in infections we have observed with the addition of vancomycin powder.

Although tobacco use is a possible risk factor for infection and other negative operative outcomes[17] we were not able to reliably assess post-operative tobacco use in this study. All of the senior surgeon's patients undergoing elective procedures were required to be nicotine free before surgery, which accounts for the low smoking rates observed in this study. We were not able to assess the rate of smoking resumption following surgery; however, it has been noted that up to 36% of this surgeon's patients who have stopped smoking prior to surgery continued to refrain from smoking postoperatively at the one-year mark (personal communication, June 20, 2012).

In conclusion, the addition of intrawound vancomycin powder to our anti-microbial prophylaxis regimen has decreased the rate of staphylococcal surgical site infections in our posterior instrumented arthrodesis surgeries. Even with the addition of intrawound vancomyin powder we did have seven infections and found that being discharged to an inpatient rehabilitation or skilled nursing facility was associated with developing these infections. This finding warrants further investigation. We recommend the addition of vancomycin powder in posterior instrumented arthrodesis surgeries to decrease staphylococcal infections and recommend strict wound care post-operatively to further decrease surgical site infections not covered by vancomycin.

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## Table 1

Demographic and Hospitalization Characteristics for Patients Receiving and Not Receiving Vancomycin Powder

| Characteristics | Vanco (N=342) | Non-Vanco (N=341) | T-test or Chi-square |
|---|---|---|---|
| Age, mean (SD) | 55.3 (19.1) | 49.1 (20.9) | p<0.0001 |
| Gender (%) | | | p=0.302 |
| Male | 45.3 | 49.3 | |
| Female | 54.7 | 50.7 | |
| Race (%) | | | p=0.101 |
| Caucasian | 85.7 | 87.7 | |
| African-American | 8.2 | 7.0 | |
| Hispanic | 1.8 | 3.5 | |
| Other | 4.4 | 1.8 | |
| Adult BMI, mean (SD) | 31.6 (7.3) | 30.7 (7.0) | p=0.130 |
| Co-morbidities (%) | | | |
| Diabetes | 18.1 | 15.0 | p=0.279 |
| Cardiovascular Disease | 17.5 | 13.3 | p=0.123 |
| Respiratory Disease | 17.5 | 14.5 | p=0.272 |
| Hypertension | 56.7 | 41.9 | P<0.001 |
| Mean ASA Grade (SD) | 2.6 (0.6) | 2.5 (0.6) | p=0.067 |
| History of Surgical Site Infection (%) | 1.8 | 3.9 | p=0.098 |
| Current Cigarette Use at Time of Surgery (%) | 5.6 | 6.5 | p=0.602 |
| Any Alcohol Use (%) | 37.1 | 24.9 | p<0.001 |
| Mean Number of Days Hospitalized Until Discharge or SSI (SD) | 5.9 (4.5) | 6.3 (4.3) | p=0.350 |
| Insurance Type (%) | | | p=0.002 |
| Commercial | 44.4 | 44.7 | |
| Medicare | 35.7 | 26.5 | |
| Medicaid | 5.9 | 13.5 | |
| Workmen's Comp | 14.0 | 15.3 | |
| Discharge Location (%) | | | p=0.077 |
| Home | 83.3 | 88.3 | |
| Inpatient Rehabilitation | 10.8 | 9.1 | |
| Skilled Nursing Facility | 5.9 | 2.6 | |

BMI= body mass index, ASA= American Society of Anesthesiologists, SSI= surgical site infection SD= standard deviation

**Table 2**

Operative Characteristics for Patients Receiving and Not Receiving Vancomycin Powder

| Characteristics | Vanco (N=342) | Non- Vanco (N=341) | T-test or Chi-square |
|---|---|---|---|
| Diagnosis (%) | | | p= 0.419 |
| Spinal Stenosis | 13.5 | 9.1 | |
| Spondylolisthesis | 33.9 | 38.7 | |
| Degenerative Disc Disease/Herniated Disc | 14.6 | 15.8 | |
| Scoliosis | 12.9 | 10.9 | |
| Pseudoarthrosis | 12.0 | 10.6 | |
| Fracture | 2.6 | 4.4 | |
| Cancer | 0.9 | 1.5 | |
| Other | 9.7 | 9.1 | |
| Blood Transfusion (%) | 30.1 | 33.0 | p=0.414 |
| Mean Number of Orthopedic Residents Involved in the Surgery (SD) | 0.81 (0.43) | 0.96 (0.38) | p<0.0001 |
| Mean Estimated Blood Loss in mL (SD) | 635 (818) | 616 (700) | p=0.747 |
| Mean Length of Surgery in minutes (SD) | 298 (125) | 312 (129) | p=0.158 |
| Mean Number of Levels Instrumented (SD) | 3.8 (3.8) | 3.6 (4.1) | p=0.607 |
| Mean Number of Levels Fused (SD) | 3.3 (3.6) | 3.3 (3.9) | p=0.973 |
| Associated Anterior Approach (%) | 20.2 | 23.8 | p=0.259 |
| Decompression (%) | 81.9 | 76.3 | p=0.071 |
| Pelvic Fixation (%) | 15.2 | 10.6 | p=0.070 |
| Operative Levels (%) | | | p=0.237 |
| Cervical | 7.0 | 5.6 | |
| Thoracic | 1.5 | 3.8 | |
| Thoraco-lumbar | 24.0 | 22.9 | |
| Lumbar | 67.5 | 67.7 | |
| Previous Surgery (%) | 50.0 | 39.8 | p=0.007 |
| Hemovac Drain Used (%) | 93.3 | 91.8 | p=0.460 |
| Hair Removal (%) | | | p<0.001 |
| Clippers | 98.8 | 92.5 | |
| Razor | 0.0 | 1.5 | |
| None | 1.2 | 6.0 | |

SD= Standard Deviation

**Table 3**

Rates of Infections in Vanco and Non-Vanco Cohorts

| Infections | Vanco (N=342) | Non-Vanco (N=341) | Chi-square/Fisher Exact |
|---|---|---|---|
| Total staphylococcal[a], number (%) | 4 (1.1) | 13 (3.8) | p=0.029 |
| Deep staphylococcal[a], number (%) | 0 | 7 (2.1) | p=0.008 |
| Deep MRSA, number (%) | 0 | 5 (1.5) | p=0.031 |
| Non-staphylococcal, number (%) | 5 (1.5) | 5 (1.5) | p=1.000 |

[a]Includes *S. aureus and* coagulase-negative staphylococcus.

MRSA= methicillin-resistant *S. aureus*

## Table 4

Demographic and Hospitalization Risk Factors for SSI for Patients Receiving Vancomycin Powder

| Characteristics | No SSI (N=335) | SSI (N=7) | T-test or Chi-square |
|---|---|---|---|
| Age, mean (SD) | 55 (19) | 49 (27) | p=0.388 |
| Gender (%) | | | p=0.243 |
| Male | 45.1 | 57.1 | |
| Female | 54.9 | 42.9 | |
| Race (%) | | | p=0.229 |
| Caucasian | 85.7 | 85.7 | |
| African-American | 8.1 | 14.3 | |
| Hispanic | 1.8 | 0 | |
| Other | 4.5 | 0 | |
| Adult BMI, mean (SD) | 31.5 (7.3) | 36.3 (5.4) | p=0.150 |
| Co-morbidities (%) | | | |
| Diabetes | 17.9 | 28.6 | p=0.469 |
| Cardiovascular Disease | 17.6 | 14.3 | p=0.819 |
| Respiratory Disease | 17.6 | 14.3 | p=0.819 |
| Hypertension | 56.7 | 57.4 | p=0.982 |
| Mean ASA Grade (SD) | 2.5 (0.59) | 2.9 (0.38) | p=0.168 |
| History of Surgical Site Infection (%) | 1.8 | 0 | p=0.883 |
| Current Cigarette Use at Time of Surgery (%) | 5.6 | 0 | p=0.668 |
| Any Alcohol Use (%) | 37.3 | 28.6 | p=0.286 |
| Mean Number of Days Hospitalized Until Discharge or SSI (SD) | 5.9 (4.4) | 7.4 (6.2) | p=0.366 |
| Insurance Type (%) | | | p=0.037 |
| Commercial | 44.8 | 28.6 | |
| Medicare | 35.5 | 42.9 | |
| Medicaid | 6.0 | 0 | |
| Workmen's Comp | 13.7 | 28.6 | |
| Discharge Location (%) | | | p=0.031 |
| Home | 57.1 | 83.9 | |
| Inpatient Rehabilitation | 14.3 | 10.8 | |
| Skilled Nursing Facility | 28.6 | 5.4 | |

BMI= body mass index, ASA= American Society of Anesthesiologists, SSI= surgical site infection

## Table 5

Operative Risk Factors for SSI in those patients receiving Vancomycin Powder

| Characteristics | No SSI (N=335) | SSI (N=7) | T-test or Chi-square |
|---|---|---|---|
| Diagnosis (%) | | | p=0.839 |
| Spinal Stenosis | 13.4 | 14.3 | |
| Spondylolisthesis | 33.4 | 57.1 | |
| Degenerative Disc Disease/Herniated Disc | 14.9 | 0 | |
| Scoliosis | 12.8 | 14.3 | |
| Pseudoarthrosis | 12.2 | 0 | |
| Fracture | 2.7 | 0 | |
| Cancer | 0.9 | 0 | |
| Other | 9.6 | 14.3 | |
| Blood Transfusion (%) | 29.9 | 42.9 | p=0.458 |
| Mean Number of Orthopedic Residents Involved in the Surgery (SD) | 0.8 (0.4) | 1.0 (0) | p<0.0001 |
| Mean Estimated Blood Loss in mL (SD) | 635 (825) | 619 (412) | p=0.943 |
| Mean Length of Surgery in minutes (SD) | 296 (123) | 367 (175) | p=0.138 |
| Mean Number of Levels Instrumented (SD) | 3.8 (3.7) | 4.9 (5.5) | p=0.447 |
| Mean Number of Levels Fused (SD) | 3.3 (3.6) | 4.6 (5.6) | p=0.567 |
| Associated Anterior Approach (%) | 20.3 | 14.3 | p=0.368 |
| Decompression (%) | 81.8 | 85.7 | p=0.385 |
| Pelvic Fixation (%) | 14.9 | 28.6 | p=0.215 |
| Operative Levels (%) | | | p=0.090 |
| Cervical | 6.9 | 14.3 | |
| Thoracic | 1.5 | 0 | |
| Thoraco-lumbar | 23.9 | 28.6 | |
| Lumbar | 67.8 | 57.1 | |
| Previous Surgery (%) | 50.5 | 28.6 | p=0.252 |
| Hemovac Drain Used (%) | 91.5 | 85.7 | p=0.419 |
| Hair Removal (%) | | | p=0.771 |
| Clippers | 98.8 | 100 | |
| None | 1.2 | 0 | |

SD= Standard Deviation