Complications associated with bacitracin powder in surgical wounds

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OBJECT There has been renewed interest in the application of concentrated antibiotic powder to surgical wounds as a method to decrease infection rates. While there is substantial medical literature describing the effectiveness and complications associated with vancomycin and gentamycin powders, very little has been reported regarding the safety and effectiveness of bacitracin powder in surgical wounds. In this paper the authors report their detailed analysis of potential bacitracin powder–related complications in a population of pediatric patients who underwent shunt surgery.

METHODS A detailed retrospective analysis was completed of all CSF shunt surgeries performed by the corresponding author at a large children’s hospital between 2001 and 2013. This cohort consisted of many patients who were the subject of a previous report that showed the use of bacitracin powder in shunt wounds potentially decreased infection rates. Data were collected regarding the most common known complications of bacitracin, i.e., anaphylaxis, wound healing difficulties, and renal dysfunction. Data were stratified by typical demographic, medical, and surgical variables, including whether bacitracin powder was applied to wounds prior to closure.

RESULTS A total of 597 patients were reviewed in the analysis: 389 underwent surgery without bacitracin powder and 208 had concentrated bacitracin powder applied to the wounds prior to closure. The application of bacitracin powder was not associated with anaphylaxis (n = 0 both groups) or with an increase in wound breakdown (n = 5 in the control group, n = 0 in the bacitracin powder group) or renal dysfunction (creatinine/estimated glomerular filtration rate) using both comparative and multivariate analyses between the 2 groups. The sample size evaluating renal function was significantly lower (range 6–320) than that of anaphylaxis and wound breakdown analysis because only clinical values acquired during the routine care of these patients were available for analysis. The only significant difference in demographics was the more frequent use of intrathecal vancomycin and gentamycin in patients who received bacitracin powder (n = 1 for controls, n = 21 for bacitracin powder). In the multivariate analysis, only 1 factor, surgery performed on a premature infant within the first 3 months of life, was independently associated with a change in creatinine at 3 months (creatinine decreased by 0.18) compared with the level before surgery (p < 0.0001). Bacitracin powder was not a significant factor.

CONCLUSIONS To the authors’ knowledge, this is the first study to systematically analyze the potential complications of concentrated bacitracin powder applied to surgical wounds. The use of topical bacitracin powder in CSF shunt wounds was not associated with anaphylaxis, wound breakdown, or renal dysfunction. Further study using standardized protocols is necessary before widespread use can be recommended.

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KEY WORDS hydrocephalus; cerebrospinal; infection; antibiotic; powder; bacitracin
risk factors for shunt infection included the presence of a tracheostomy or a gastrostomy tube. The only protective factor for shunt infection was the application of bacitracin powder just prior to wound closure. Future randomized controlled trials have been suggested before the use of topical antibiotics can be widely recommended.

The properties of bacitracin make it an ideal candidate for local administration. At a concentration of 200 U/ml, bacitracin demonstrated a bactericidal “kill” of greater than 90% at 1 hour and 50% after only 1 minute. Bacitracin also exhibits some detergent properties (which is why it causes solutions to froth). Experiments have shown a 54% reduction in bacterial adherence after only a 30-minute exposure to bacitracin. Therefore, the use of local bacitracin combines both bactericidal and adherence reduction properties to prevent infection.

The complications of intravenous and intramuscular bacitracin have been well described, including renal dysfunction, anaphylaxis, and impaired wound healing. However, the potential adverse effects from topical administration of bacitracin into wounds has not been extensively studied. To more thoroughly address these concerns, we further scrutinized the medical records from our patient cohort in the bacitracin powder shunt study, specifically analyzing patient outcomes related to the potential complications of using topical high-dose bacitracin powder.

Methods

Study Population

This study was approved by the Institutional Review Board of All Children’s Hospital in St. Petersburg, Florida. In the current study, we reanalyzed the same patient cohort previously used to study the effect of bacitracin powder on CSF shunt infection rates in children over a 10-year period. Of the 658 patients who underwent surgery by the corresponding author (G.F.T.) at All Children’s Hospital during that time period, we previously reported on 539 patients who had at least 180 days of follow-up, to assess shunt infection. In the current study of the possible complications associated with bacitracin powder use, we included patients with a minimum follow-up of 90 days, which allowed us to analyze 597 of the 658 patients who underwent surgery during the designated time period.

Data Collection

A retrospective chart review of all cranial shunt procedures between January 2001 and March 2013 was performed to specifically assess preoperative and postoperative renal function, anaphylaxis, and wound breakdown. Our re-review of the patient data included detailed analysis of operative reports, anesthesia records, physician and nursing notes, and laboratory values, carefully searching for any signs of wound breakdown, anaphylaxis, or renal dysfunction.

All procedures were performed at a freestanding children’s hospital and included patients’ ages, ranging from 1 day to 24 years. This was a primarily pediatric population, with the exception of a few adults who could not be transferred during acute shunt malfunction.

Bacitracin powder was systematically applied to all shunt wounds prior to closure between 2008 and 2013, whereas no antibiotic powder was applied to wounds prior to 2008. When bacitracin powder was used in this study, it was placed in all wounds but not in a precise dose-dependent manner. Our intent was to fill each wound completely with bacitracin powder. Typically, an entire bottle (50,000 units) was dispersed among the wounds of children of adult size, while smaller doses were used for infants. For neonates and young children, approximately one-half of a bottle (25,000 units) was required to fill the wounds. For mini-open laparotomies, the rectus sheath was closed prior to bacitracin powder administration to avoid intraperitoneal contamination. Please refer to our previous study for the precise surgical technique.

Renal function was determined by recording preoperative creatinine and estimated glomerular filtration rate (eGFR) and comparing those values to both the immediate postoperative and 3-month follow-up. The glomerular filtration rate was estimated using the modified Schwartz estimating equation \[\text{eGFR} = (0.413 \times \text{height [in cm]})/\text{serum creatinine (mg/dl)}\]. Preoperative creatinine and eGFR were defined as values obtained within 2 days of surgery; immediate postoperative creatinine and eGFR were defined as values obtained within 1 week of surgery; and delayed creatinine and eGFR were defined as values obtained at approximately 3 months (± 1 month) after surgery. Creatinine values were derived from review of the medical records, reflecting blood levels that were routinely measured in the course of the patients’ routine medical care. No effort was made to measure additional levels for the purpose of this study.

All inpatient and outpatient records were carefully scrutinized for any clinical notes from nephrology within 1 year of surgery. If there were any notes from nephrology, they were analyzed for any suggestion of new renal dysfunction after surgery.

Statistical Analysis

Data were analyzed to compare changes in creatinine and eGFR between the different time periods within and between the 2 treatment groups (bacitracin powder vs no bacitracin powder used). Numerical variables were compared using the Wilcoxon-Mann-Whitney test and categorical variables were compared using chi-square or Fisher’s exact tests. Multivariate linear regression models were used to assess the effect of the following factors on the change in creatinine at 1 week and at 3 months when compared with creatinine before surgery: age, sex, operation performed on a premature infant within the first 90 days of life, number of shunt operations within 90 days of index operation, operative time, use of intrathecal vancomycin and gentamycin, and use of bacitracin powder. This multivariate analysis was designed a priori, based on the analyzable factors that were believed could influence renal function and/or have been described in previous studies to be related to renal function in this setting. We did not report a similar multivariate analysis of eGFR because there was so much missing data related to height in the control group. All statistical analyses were performed using SAS (version 9.3, SAS Institute Inc.) and p values < 0.05 were considered statistically significant.
Results

Our database contained information on 597 shunt procedures (initial and revision) performed by the corresponding author between 2001 and 2013. Three hundred eighty-nine patients underwent surgery without bacitracin powder and 208 had concentrated bacitracin powder applied to the wounds prior to closure. Renal function was measured preoperatively (n = 237 for controls, n = 172 for bacitracin), immediately postoperatively (n = 320 for controls, n = 98 for bacitracin), and at least 3 months postoperatively (n = 104 for controls, n = 77 for bacitracin) in both the historical control group (no powder) and the bacitracin powder group. It is atypical for these values to be measured in a pediatric population, but when available, they were recorded. This is noted in Table 1, in which varying numbers of patients were evaluated for renal function (range 6–320 patients). There were no statistically significant differences in the demographics between the patients who did and did not receive bacitracin powder (including baseline renal dysfunction or the incidence of spina bifida), except for more frequent use of intrathecal vancomycin and gentamycin in the patients who received bacitracin powder (Table 2). Intrathecal antibiotics always included both vancomycin and gentamycin given dose-dependently: if the patient was less than 3 months of age, 5 mg of vancomycin and 1 mg of gentamycin were given; if the child was older than 3 months, 10 mg of vancomycin and 2 mg of gentamycin were given.

Comparison of Creatinine and eGFR Between the Control and Bacitracin Powder Groups at 3 Different Time Intervals

There were no statistically significant differences in creatinine when comparing levels drawn before surgery, within the first week of surgery, and at 3 months after surgery. This was a consistent finding when comparing the overall results. However, when stratifying the data according to whether bacitracin powder was administered, there was a significant difference in the values found within the first week of surgery (median 0.50 in the control group vs 0.41 in bacitracin powder group; p < 0.001; Table 1). When performing the same analysis with eGFR, there were no statistically significant differences in eGFR when comparing the eGFR levels between the groups at any time interval (Table 1).

Comparing the Change in Creatinine and eGFR Between the Control and Bacitracin Powder Groups

When calculating the change in creatinine for each patient over time, there were no statistically significant differences when comparing the patients who had bacitracin powder to those who did not (Table 1). For patients who had creatinine levels before and after surgery, the median change in creatinine in the control group (no powder) immediately after surgery and at 3 months was zero. In patients who received bacitracin powder, there was no increase in creatinine in the immediate postoperative period and a median decrease of 0.01 mg/dl at 3 months when compared with their levels drawn before surgery (Table 1).

Calculating eGFR requires not only creatinine levels but also the patient’s height. Because height measurements were often not recorded in the early cohort (no powder), comparisons of eGFR between patients who did and did not receive bacitracin powder are limited. Given these

<table>
<thead>
<tr>
<th>Variable</th>
<th>No Powder</th>
<th>Bacitracin Powder</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anaphylaxis (no/yes)</td>
<td>389</td>
<td>208</td>
<td>0.89</td>
</tr>
<tr>
<td>No</td>
<td>389</td>
<td>208</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Yes</td>
<td>0</td>
<td>0</td>
<td>0.31</td>
</tr>
<tr>
<td>Wound breakdown</td>
<td>389</td>
<td>208</td>
<td>0.17</td>
</tr>
<tr>
<td>No</td>
<td>384</td>
<td>208</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>5</td>
<td>0</td>
<td>0.30</td>
</tr>
<tr>
<td>Creatinine (mg/dl)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Before surgery</td>
<td>237</td>
<td>0.40 (0.2–1.1)</td>
<td>172</td>
</tr>
<tr>
<td>First week</td>
<td>320</td>
<td>0.50 (0.1–1.3)</td>
<td>98</td>
</tr>
<tr>
<td>3 mos</td>
<td>104</td>
<td>0.40 (0.2–1.0)</td>
<td>77</td>
</tr>
<tr>
<td>Change in creatinine in first wk*</td>
<td>210</td>
<td>0.00 (–0.5 to 0.4)</td>
<td>84</td>
</tr>
<tr>
<td>Change in creatinine in 3 mos†</td>
<td>76</td>
<td>0.00 (–0.3 to 0.3)</td>
<td>69</td>
</tr>
<tr>
<td>eGFR (ml/min)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Before surgery</td>
<td>31</td>
<td>135.7 (19.1–210.4)</td>
<td>136</td>
</tr>
<tr>
<td>First wk</td>
<td>27</td>
<td>97.9 (20.3–217.3)</td>
<td>75</td>
</tr>
<tr>
<td>3 mos</td>
<td>12</td>
<td>119.3 (36.0–275.0)</td>
<td>64</td>
</tr>
<tr>
<td>Change in eGFR in first wk*</td>
<td>24</td>
<td>0.00 (–68.6 to 72.4)</td>
<td>69</td>
</tr>
<tr>
<td>Change in eGFR in 3 mos†</td>
<td>6</td>
<td>–26.4 (–70.3 to 110.0)</td>
<td>54</td>
</tr>
</tbody>
</table>

* Value in first week subtracted from value before surgery.
† Value at 3 months subtracted from value before surgery.
limitations, when analyzing the change in eGFR for each patient over time, the median eGFR remained unchanged in the control group in the initial postoperative period but it increased by 2.62 ml/min in the patients who had bacitracin powder (p = 0.12). At 3 months, the median eGFR decreased in the control patients (no powder) but increased in the patients who received bacitracin powder. Unfortunately, the limited height data available from the control group limits the conclusions that can be drawn regarding changes in eGFR (Table 1).

Comparing Renal Function Between Participants Who Received Intrathecal Antibiotics Within the Bacitracin Powder Cohort

Few patients received intrathecal antibiotics within the bacitracin cohort (n = 21). This relatively small sample size leads to very limited conclusions. Notwithstanding, there was no significant change in renal function defined by creatinine and eGFR between the preoperative state and both the immediate postoperative period and 3-month follow-up for either the intrathecal antibiotic subgroup or the nonintrathecal antibiotic subgroup (Table 3).

Multivariate Analysis of Factors Related to a Change in Creatinine

Lastly, as part of an a priori hypothesis, a multivariate analysis of all patients was performed to determine if other factors could contribute to a change in creatinine from the preoperative value to both the immediate postoperative and delayed postoperative values (Table 4). Once again, due to the unpredictable pattern of collecting renal function values in these patients, our sample size was only 290 at 1 week and 145 at 3 months. Only surgery performed on a premature infant within the first 3 months of life was associated with a significant change in creatinine at 3 months compared with the level before surgery (p < 0.0001). The use of bacitracin powder was not significantly associated with a change in creatinine at either time interval in this model.

Post Hoc Analysis

To determine a change in creatinine in the first week after surgery, with 290 participants included in the multivariate linear regression and 8 predictors, we had greater than 90% power to observe a change of 0.02 in creatinine with a standard error of 0.02 at the 2-sided α level of 0.05. To determine a change in creatinine after the first 3 months of surgery, with 145 participants included in the multivariate linear regression and 8 predictors, we had greater than 90% power to observe a change of 0.02 in creatinine with a standard error of 0.02 at the 2-sided α level of 0.05.

Nephrology Consultations for New Renal Dysfunction After Surgery

Only 2 patients had a new nephrology consultation after their shunt operation, neither of which was related to new renal dysfunction after their operation. One patient was evaluated by a nephrology specialist because of recurrent urinary tract infections and the other was examined because of chronically low bone mineral density.

Discussion

Our group began applying concentrated bacitracin powder to all CSF shunt wounds more than 6 years ago. Our retrospective analysis of shunt infection over 10 years, divided between periods when bacitracin was and was not used, suggested that a reduction in shunt infection was at least partially associated with the use of bacitracin powder. However, given the limitations of a retrospective study, prospective controlled trials are required before this practice can be broadly recommended. We conducted the analysis in this report to further study the possible complications associated with applying high-dose bacitracin directly to surgical wounds prior to closure. This safety information is important for future studies.

Our current study confirmed both our clinical impressions and preliminary analysis, i.e., that the application of concentrated bacitracin powder in high doses was not associated with anaphylaxis or an increased rate of wound breakdown or renal dysfunction. Both comparative and multivariate analyses showed that bacitracin powder was not associated with an increase in creatinine (Tables 1

### Table 2. Variable frequency with and without bacitracin powder

<table>
<thead>
<tr>
<th>Variable</th>
<th>No Powder</th>
<th>Bacitracin Powder</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of patients</td>
<td>389</td>
<td>208</td>
<td></td>
</tr>
<tr>
<td>Age (mos)</td>
<td></td>
<td></td>
<td>0.32</td>
</tr>
<tr>
<td>Median</td>
<td>105</td>
<td>82</td>
<td></td>
</tr>
<tr>
<td>Range</td>
<td>0.03–290</td>
<td>0.07–250</td>
<td></td>
</tr>
<tr>
<td>Sex (%)</td>
<td></td>
<td></td>
<td>0.79</td>
</tr>
<tr>
<td>Female</td>
<td>197 (51)</td>
<td>103 (50)</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>192 (49)</td>
<td>105 (50)</td>
<td></td>
</tr>
<tr>
<td>Spina bifida (%)</td>
<td></td>
<td></td>
<td>0.25</td>
</tr>
<tr>
<td>No</td>
<td>319 (84)</td>
<td>166 (80)</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>60 (16)</td>
<td>41 (20)</td>
<td></td>
</tr>
<tr>
<td>Missing</td>
<td>10</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Premature infant (%)</td>
<td></td>
<td></td>
<td>0.08</td>
</tr>
<tr>
<td>No</td>
<td>361 (95)</td>
<td>198 (95)</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>19 (5)</td>
<td>10 (5)</td>
<td></td>
</tr>
<tr>
<td>Missing</td>
<td>9 (2)</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>History of renal dysfunction (%)</td>
<td></td>
<td></td>
<td>0.07</td>
</tr>
<tr>
<td>No</td>
<td>389 (100)</td>
<td>206 (99)</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>0 (0)</td>
<td>2 (1)</td>
<td></td>
</tr>
<tr>
<td>Operative time (min)</td>
<td></td>
<td></td>
<td>0.33</td>
</tr>
<tr>
<td>Median</td>
<td>41</td>
<td>42</td>
<td></td>
</tr>
<tr>
<td>Range</td>
<td>3–267</td>
<td>15–146</td>
<td></td>
</tr>
<tr>
<td>Mean shunt revisions within 90 days ± SD</td>
<td>0.7 ± 1.3</td>
<td>0.5 ± 0.9</td>
<td>0.07</td>
</tr>
<tr>
<td>Intrathecal vancomycin &amp; gentamycin (%)</td>
<td></td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>388 (100)</td>
<td>187 (90)</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>1 (0)</td>
<td>21 (10)</td>
<td></td>
</tr>
</tbody>
</table>

* Surgery performed on a premature infant within the first 90 days of life.
and 4). Furthermore, a significant change in creatinine was only associated with premature infants undergoing surgery in the first 90 days of life. This finding of significant fluctuations in creatinine in premature infants is not surprising, considering the dramatic changes in creatinine that normally occur shortly after birth.8

To our knowledge, this is the first study to systematically analyze the safety of high-dose bacitracin powder applied to surgical wounds prior to closure. Our analysis of wound breakdown and anaphylaxis was straightforward, but the analysis of renal function was more difficult because of the retrospective nature of this study. The greatest limitation of our study is related to the large number of missing creatinine levels, which are not uniformly drawn on all patients undergoing shunt surgery, before or after the operation. Our sample size varied greatly, ranging from 6 to 320 (Table 1). It is theoretically possible that patients might have developed renal dysfunction without a creatinine level being drawn within 3 months of surgery. However, we believe it is unlikely given that no patient had a nephrologist consultation for new renal dysfunction after surgery.

Another limitation to our study is related to the way we measure the effect of bacitracin on the kidneys. While the measurement of creatinine is the most widely used marker of renal function, it is an imperfect marker.8 For example, it is not sensitive to small changes in renal function and is linked to muscle mass and body weight, which can vary greatly in newborns.8 Estimating the glomerular filtration rate, on the other hand, takes patient height into account and is believed to be a better measure of renal function. Unfortunately, patient heights were rarely recorded in the

<table>
<thead>
<tr>
<th>Variable</th>
<th>No Intrathecal Antibiotic</th>
<th>Intrathecal Antibiotic</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of cases</td>
<td>187</td>
<td>21</td>
</tr>
<tr>
<td>Creatinine (mg/dl)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Before surgery</td>
<td>155</td>
<td>0.42 (0.1–6.1)</td>
</tr>
<tr>
<td>First week</td>
<td>85</td>
<td>0.43 (0.1–8.1)</td>
</tr>
<tr>
<td>3 mos</td>
<td>68</td>
<td>0.38 (0.1–0.9)</td>
</tr>
<tr>
<td>Change in creatinine in first wk*</td>
<td>73</td>
<td>−0.02 (−0.22 to 2.00)</td>
</tr>
<tr>
<td>Change in creatinine in 3 mos†</td>
<td>60</td>
<td>0.00 (−0.49 to 0.55)</td>
</tr>
<tr>
<td>eGFR (ml/min)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Before surgery</td>
<td>123</td>
<td>121.67 (9.55–425.33)</td>
</tr>
<tr>
<td>First week</td>
<td>65</td>
<td>127.54 (7.19–325.77)</td>
</tr>
<tr>
<td>3 mos</td>
<td>56</td>
<td>128.56 (54.14–429.0)</td>
</tr>
<tr>
<td>Change in eGFR in first wk*</td>
<td>60</td>
<td>3.29 (−97.73 to 66.66)</td>
</tr>
<tr>
<td>Change in eGFR in 3 mos†</td>
<td>48</td>
<td>8.74 (−71.05 to 51.11)</td>
</tr>
</tbody>
</table>

* Value in first week subtracted from value before surgery.
† Value at 3 months subtracted from value before surgery.

SEM = standard error of the mean.

* Surgery performed on a premature infant within the first 90 days of life.
† Immediate postoperative value subtracted from preoperative value.
‡ Delayed postoperative value subtracted from preoperative value.
control group, which consisted of patients who had surgery in the early 2000s, when electronic medical record entries were less robust than they were in the later cohort. This resulted in a significant amount of missing data for the eGFR in our historical cohort. However, when we strictly analyzed patients who only received bacitracin powder, who underwent surgery more recently and consequently had their heights routinely recorded, their average eGFRs actually increased during the 3 months after surgery (Table 1).

The potential for nephrotoxicity has been documented with both intravenous and intramuscular administration of bacitracin.18–20,23,30 Ericsson et al. also evaluated its use in peritoneal lavage for preventing laparotomy infections. In their small series of 9 patients, 50,000 units of bacitracin was mixed with 200 ml of normal saline and used as lavage in the peritoneal cavity. Peak concentrations after 15 minutes exceeded that of intramuscular doses and were tantamount to intravenous administration of bacitracin.7 Consequently, they recommend extreme caution when using bacitracin in the peritoneal cavity. Bacitracin has been essentially abandoned as a systemic antibiotic and promoted for local use.

In our study, it was common for 50,000 units of bacitracin to be dispersed among all the shunt wounds in each patient. Although we did not directly measure serum levels of bacitracin (this lab value was not available at our institution), there were no significant clinical effects encountered with its local administration. This is not surprising given the location and size of shunt wounds. The majority of bacitracin powder was placed in the subgaleal space of the small cranial wounds after meticulos hemostasis was achieved. Even with the potential of tracking along the shunt tubing, a significant amount of systemic absorption is still unlikely to equal that of intramuscular or peritoneal absorption due to the nature of the tissue in which the shunt resides.

Both the trocar technique and mini-open laparotomy technique were used for peritoneal placement of the distal catheter. For the trocar method, the incision is just too small for a significant amount of bacitracin powder to track into the peritoneum, and for the mini-open laparotomy technique, bacitracin was only applied after the rectus sheath was closed. Therefore, no significant amount of powder could reach the peritoneal cavity.

Conclusions

The use of local bacitracin powder in CSF shunt wounds was not associated with anaphylaxis, wound breakdown, or renal dysfunction. Further study using standardized protocols is necessary before widespread use of bacitracin powder can be recommended.

References

after local neomycin/polymyxin application. J Neurosurg
110:247–250, 2009
22. Molinari RW, Khera OA, Molinari WJ III: Prophylactic in-
traoperative powdered vancomycin and postoperative deep
spinal wound infection: 1,512 consecutive surgical cases over
23. Prier JE, Thomas RM, Bingham DA: Intramuscular bacitra-
cin therapy in sheep. Cornell Vet 43:38–43, 1953
24. Savitz SI, Savitz MH, Goldstein HB, Mouracade CT, Malan-
gone S: Topical irrigation with polymyxin and bacitracin for
25. Stall AC, Becker E, Ludwig SC, Gelb D, Poelstra KA: Re-
duction of postoperative spinal implant infection using gen-
tamicin microspheres. Spine (Phila Pa 1976) 34:479–483,
2009
tion of the revised Schwartz estimating equation in a pre-
2326, 2010
27. Sweet FA, Roh M, Sliva C: Intrawound application of van-
comycin for prophylaxis in instrumented thoracolumbar
fusions: efficacy, drug levels, and patient outcomes. Spine
28. Theophilus SC, Adnan JS: A randomised control trial on the
use of topical mexitilin in reducing post-operative ventricu-
loperitoneal shunt infection. Malays J Med Sci 18:30–37,
2011
29. Yarboro SR, Baum EJ, Dahners LE: Locally administered
antibiotics for prophylaxis against surgical wound infection.
30. Zintel HA, Ma RA, Nichols AC, Ellis H: The absorption,
distribution, excretion and toxicity of bacitracin in man. Am

Disclosure
The authors report no conflict of interest concerning the materi-
als or methods used in this study or the findings specified in this
paper.

Author Contributions
Conception and design: Tuite, Perlman. Acquisition of data:
Tuite, Tetreault. Analysis and interpretation of data: Tuite, Beck-
man, Perlman. Drafting the article: Beckman. Critically revising
the article: all authors. Reviewed submitted version of manu-
script: all authors. Approved the final version of the manuscript
on behalf of all authors: Tuite. Statistical analysis: Amankwah.
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