Intraoperative Powdered Vancomycin Use With Paddle Lead Placement

Jacob Amrani, MD

**Objectives:** This is a prospective case-control study that was conducted to determine if the addition of intraoperative powdered vancomycin placed directly into the wounds at the time of closure might decrease the rate of acute postoperative infection after the placement of spinal cord stimulator paddle leads.

**Materials and Methods:** A retrospective analysis of the author’s practice from January 1, 2009 through July 31, 2012 (Table 1) showed that those patients requiring a laminectomy instead of a laminotomy to insert a paddle lead had an increased rate of acute postop infection. All patients receiving a thoracic spinal cord stimulator paddle from January 1, 2013 through December 31, 2013 were then followed prospectively. Those patients whose paddle leads could be inserted with a laminotomy were treated in a standard fashion. Those patients who required a laminectomy for insertion of the paddle lead received powdered vancomycin placed directly into the wounds prior to closure.

**Results:** One hundred and nine patients underwent implantation of a permanent spinal cord stimulator paddle lead and battery between January 1 and December 31, 2013. Thirty-two of those patients required a laminectomy for implantation of the paddle and received intraoperative powdered vancomycin placed directly into both wounds at the time of closure. The remaining 77 patients were treated in a standard fashion. There were no infections in the laminectomy group and two infections in the laminotomy group.

**Conclusion:** This study indicates that intraoperative powdered vancomycin placed directly into the wounds at the time of closure can produce similar infection rates between the groups of patients requiring a laminectomy vs. a laminotomy for implantation of a thoracic paddle lead. These findings need confirmation by a randomized controlled design study.

**Keywords:** Infection, neuromodulation, paddle leads, vancomycin

**Conflicts of Interest:** The author reported no conflict of interest.

INTRODUCTION

Infection following the implantation of permanent spinal cord stimulators has been consistently reported at 4–5% (1–6). The same rate has been reported for permanent percutaneous leads as for paddle leads. The rate also does not seem to vary between the thoracic spine and the cervical spine, nor has the rate changed from 1997 to 2011. The few papers that address techniques to avoid infection in these cases (7) make general recommendations such as for the administration of perioperative antibiotics. Although some of the authors referenced above were able to salvage some systems with oral antibiotics and found the infections to be limited to the battery site or the lead site, neither has been this author’s experience. All infections seen by the current author have involved both sites, as proven by intraoperative cultures, and none has resolved with oral antibiotics. In each case, the stimulator lead and battery had to be removed. Subsequent reimplantation has proven a challenge.

Currently used techniques provide adequate infection prophylaxis for 95% of patients. It is the remaining 5% that require extra consideration. Recent reports (8,9) have documented the efficacy and safety of applying powdered vancomycin directly into the wound at the time of closure to decrease the infection rate after instrumented posterior spinal procedures. Although the control group in O’Neill’s series had an infection rate of 13%, the control group in Pahys’ series had an infection rate of less than 2%. The concerns related to the development of antibiotic-resistant organisms by using IV vancomycin for all surgical patients may also apply to the indiscriminate use of powdered vancomycin in all surgical wounds. With this in mind, the current author examined a subset of his patients to identify the factors associated with infection in his practice. Patients with this factor were then treated prospectively with intraoperative powdered vancomycin.

This is a prospective, case-control study that was conducted to determine whether the addition of intraoperative powdered vancomycin could decrease the acute postop infection rate following the implantation of spinal cord stimulator paddle leads in the thoracic spine in patients who require a laminectomy.

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MATERIALS AND METHODS

Subjects
To determine the patients most at risk for infection, a review of the author’s cases from January 1, 2009 through July 31, 2012 was performed. During this time frame, 646 patients underwent a primary implantation of a permanent spinal cord stimulator paddle lead. Eleven of those patients developed acute, deep infections requiring removal of the implants for an infection rate of 1.7%. No superficial infections were seen, and in the two patients in whom it was tried, oral antibiotics alone failed to resolve the postop wound drainage. In these 11 infections, cultures were positive for the same organism in both wounds, even if one of the incisions appeared benign. A sample of 85 consecutive patients, who were implanted from January 1, 2012 through July 31, 2012 (to eliminate learning curve and any changes to technique as confounding factors) and did not develop infections, served as controls. The analysis of variance was used to examine the significance of the following factors in the development of infection: patient age, gender, body mass index (BMI), history of diabetes, smoking history, the length of the stimulator trial preoperatively, the stimulator brand, the facility at which the procedure was performed, the antibiotic given perioperatively (cefazolin vs. vancomycin), the region of the spine implanted (cervical vs. thoracic), and the technique required to implant the device (laminotomy vs. laminectionomy). From January 1, 2013 through December 31, 2013, all patients implanted with a paddle stimulator in the thoracic spine were monitored prospectively for the development of acute postoperative infection. All patients were followed for a minimum of two months, as the first 11 infections all presented within this time frame. All patients requiring a laminectionomy to insert the paddle lead received intraoperative powdered vancomycin. Those patients who could be implanted through a laminotomy had a standard closure without the addition of powdered vancomycin.

Procedure
Since the author’s infection rate prior to the introduction of powdered vancomycin was already one-third that of the rate reported in the literature, only the salient points of the procedure will be reviewed. All patients were asked to shower with Hibiclens 4% Solution (Molnlycke, Norcross, GA, USA) each morning beginning two days before the surgical procedure and received nasal Bactroban (GlaxoSmithKline, Research Triangle Park, NC, USA) in the preop area. Those patients who were allergic to penicillin and those patients who had a history of prior infection in any area of the body were given 1 g of vancomycin intravenously over one hour beginning in the preop area. This was followed by another gram of IV vancomycin 12 hours later. All other patients received 2 g of Cefazolin intravenously on induction, followed by 2 g IV every eight hours for two doses. The postop antibiotic protocols were not altered if the patient received intraoperative powdered vancomycin.

All paddle implantation procedures were performed in a standard operating suite under general anesthesia. Chloraprep (CareFusion, San Diego, CA, USA) was used to sterilize the skin, and the surgical area was sealed off with loban (3M, St. Paul, MN, USA) in all patients. No adverse reactions to the loban were noted in any patient, even if an allergy to iodine was reported. Once the incision was made, the door to the operating room was cordoned off, and all traffic into and out of the room was kept to a minimum and directed through the sterile core.

The spinous process of the target vertebra and the caudal lamina were removed completely. No attempt was made to insert any device in a minimally invasive fashion. Any fibrous tissue in the epidural space from the trial leads was disrupted with a Penfield 4 elevator until the dura was clearly visible from one end of the laminotomy to the other. No dural separators were used in this series. The epidural space and laminotomy wound were irrigated with a single bulb syringe containing sterile water. Pulsatile lavage was not used.

The paddle lead was passed beneath the lamina and its position checked with fluoroscopy. If the paddle did not slide easily into the epidural space, or if the C-arm showed the lead diverging laterally after more than two passes, the superior portion of the incision was extended cephalad, and another laminotomy was performed at the next level up. This is frequently the site of additional adhesions. In addition, a partial laminectomy at the original level for implantation was performed. (The author prefers to preserve a portion of the target lamina if possible, as this helps stabilize the implant.)

After satisfactory seating of the implant, the tails were anchored to the next caudal spinous process. If a simple laminotomy had been performed, both wounds were closed in layers after implantation of the generator into a standard subcutaneous pocket above the posterior iliac crest. If a laminectomy had been performed, half a gram of powdered vancomycin was placed into the thoracic wound directly onto the spine and muscle layer. The other half of the gram of vancomycin was placed into the subcutaneous pocket for the generator, and both wounds were closed in layers. Each wound received a single 4 × 4 dressing folded in half and was covered with Tegaderm (3M, Minneapolis, MN, USA). No steri strips or dermabond was used. No drains were used in this series.

All patients with fever, drainage and elevated peripheral white cell count, sedimentation rate, and/or C-reactive protein were considered to have a deep infection. These patients were readmitted for removal of the implants, cultures of both wounds, and irrigation and debridement of both wounds and administration of IV antibiotics.

Statistics
In the retrospective practice analysis, the factors examined for an association with infection were brand of implant (Boston Scientific, Valencia, CA, USA or St. Jude, Plano, TX, USA), patient age, BMI, history of diabetes, smoking history, the technique used to implant the lead (laminotomy vs. laminectionomy), the length of time the trial leads were in place preoperatively, the perioperative intravenous antibiotic used (Cefazolin or vancomycin), the facility at which the implantation was performed (Scottsdale or Banner), the area of the spine implanted (cervical vs. thoracic), and the patient gender. An Excel spreadsheet (Microsoft, Redmond, WA, USA) was used to

<p>| Table 1. F Values for the Initial Practice Analysis. |
|-----------------|---|---|---|---|---|---|---|---|</p>
<table>
<thead>
<tr>
<th>Brand</th>
<th>Age</th>
<th>BMI</th>
<th>Diabetes</th>
<th>Smoking hx</th>
<th>Technique</th>
<th>Trial length</th>
<th>Abx</th>
<th>Facility</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>0.329</td>
<td>3.1</td>
<td>1.703</td>
<td>2.997</td>
<td>0.201</td>
<td>4.397</td>
<td>0.001</td>
<td>3.1</td>
</tr>
</tbody>
</table>
| BMI, body mass index; hx, history; Abx, antibiotic.
 POWDERED VANCOMYCIN FOR PADDLE LEAD PLACEMENT

Table 2. $F$ Values for Groups With and Without Intraoperative Powdered Vancomycin.

<table>
<thead>
<tr>
<th></th>
<th>Infection</th>
<th>Age</th>
<th>BMI</th>
<th>Diabetes</th>
<th>Smoking</th>
<th>Brand</th>
<th>Sex</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ave with vancomycin</td>
<td>53 ± 15</td>
<td>30 ± 6</td>
<td>22%</td>
<td>38%</td>
<td>69%</td>
<td>47% St. Jude</td>
<td>47% Male</td>
</tr>
<tr>
<td>Ave without vancomycin</td>
<td>53 ± 13</td>
<td>32 ± 7</td>
<td>31%</td>
<td>34%</td>
<td>76%</td>
<td>43% St. Jude</td>
<td>43% Male</td>
</tr>
<tr>
<td>$F$</td>
<td>0.830</td>
<td>0.023</td>
<td>1.89</td>
<td>0.941</td>
<td>0.135</td>
<td>0.719</td>
<td>2.42</td>
</tr>
</tbody>
</table>

BMI, body mass index.

RESULTS

Table 1 shows the $F$ values that were calculated using the analysis of variance for the retrospective practice analysis. Since there are only two groups (those with infections and those without), there is only one degree of freedom between the groups. Since there are 96 patients combined in the two groups, there are 94 degrees of freedom within the groups. The critical values table for $F$ shows that, for 94 degrees of freedom, an $F > 3.94$ corresponds to a $p < 0.05$. Only the technique used to implant the paddle lead (laminectomy vs. laminotomy, $F = 4.397$) proved to be statistically significantly associated with acute, postoperative infection requiring removal of the implants. Fifty-five percent of the patients (six of 11) with infections required laminectomies to implant the paddle leads, whereas only 30% (25 of 85) of the control group required a laminectomy.

In the prospectively followed group, 32 patients required a laminectomy for implantation of the paddle lead and received intraoperative powdered vancomycin. Seventy-seven other patients were implanted through a laminotomy and did not receive any intraoperative powdered vancomycin. Of the 109 patients, there were 48 male subjects and 61 female subjects. The average age was 53 in each group. There were two infections in the laminotomy group that required removal of the implants and six weeks of intravenous antibiotics. There were no infections in the laminectomy group. Table 2 shows the $F$ values for the prospectively followed group. For this group with 107 degrees of freedom, an $F$ value greater than 3.94 corresponds to a $p < 0.05$.

There was no statistical difference in the infection rate between the laminectomy group that received intraoperative powdered vancomycin and the laminotomy group that did not. There was no difference in the demographics between the laminotomy and laminectomy groups with respect to age, sex, BMI, diabetes, or smoking history. There was no difference between the groups with respect to the percentage of patients who received each brand of stimulator. Twenty-two percent of the laminotomy patients received intravenous vancomycin for perioperative prophylaxis compared with 25% of the laminectomy patients (who also received the intraoperative powdered vancomycin). The difference in the rate of intravenous vancomycin use between these two groups was not statistically significant with an $F$ value of 0.11. No adverse effects were noted with the use of the intraoperative powdered vancomycin, although postoperative lab work to rule out renal dysfunction, neutropenia, or thrombocytopenia was not obtained, and no audiometry testing was performed to rule out hearing loss. There were no cases of “red-man syndrome” or diarrhea to suggest infection with Clostridium difficile.

Fisher’s exact test showed no significant difference in the overall infection rate when powdered vancomycin was added to the protocol for implantation compared with the retrospective group. However, it should be noted that the only two patients who developed infections in the prospectively followed group did not receive powdered vancomycin.

DISCUSSION

Spincemaille et al. (1) reported an infection rate of 5% in 127 patients treated with the Itrel II implant (Medtronic) for lower extremity ischemia. Quigley et al. (2) reported an infection rate of 4.9% in 102 patients receiving permanent implants for chronic pain. Andersen (3) reported an infection rate of 5% in 60 patients receiving spinal cord stimulators for chronic angina pectoris. Rudiger and Thomson (4) reported an infection rate of 4.4% during a two-stage implantation of permanent percutaneous leads. Simpson et al. (5) reported a 4.8% infection rate in 41 patients implanted with the Resume lead (Medtronic) in the cervical spine. Likewise, Whitworth and Feler (6) reported a 5% infection rate in 20 patients who received paddle leads in the upper cervical spine.

Powdered vancomycin applied directly into the wound at the time of closure has been shown to bring the infection rate to zero in posterior spinal instrumentation cases (8,9). A recent study (10) in rabbits showed that intrawound vancomycin eradicated surgical wound contamination. Applying this principle to all patients in the current practice would mean 98% of patients would be receiving the powdered vancomycin unnecessarily. The hospital’s cost for 1 g of powdered vancomycin is $3.85 (cost to the patient, $385). This is insignificant compared with the cost of removing the implants, administering IV antibiotics for six weeks, and inserting new implants at a later date. However, the threat of developing antibiotic-resistant organisms cannot be ignored (11,12). Therefore, the current author chose to try to identify those patients most at risk for infection in his practice.
In the current author's practice analysis, only the performance of a laminectomy at the time of lead insertion was found to be statistically significantly associated with acute postop infection. A laminectomy involves extra dissection and bone removal and results in a greater operating time and a larger dead space postoperatively. This may pose an increased risk of infection when this technique is employed. This may also explain why percutaneous leads may be salvageable with oral antibiotics and why some authors have noted infections at only the generator or the lead site in the percutaneous cases. Patient age, gender, BMI, and smoking history were not statistically different in the group with infection compared with the group without infection in this series. All patients with a history of diabetes were placed on an 1800-Kcal ADA diet and a sliding scale insulin protocol during their 23-hour stay in the hospital. Tight regulation of the patients’ blood glucose during the first 23 hours postoperatively may have contributed to the lack of statistical significance for diabetes noted in this review. The choice of manufacturer and perioperative antibiotic also was not statistically associated with infection in the initial analysis. Although there was no statistical difference in the rate of infection between cervical and thoracic cases, the author had only one cervical infection in a patient early in his experience who had a laminectomy of C5 and was receiving immunosuppressive medication. The current technique used in the cervical spine does not require a laminectomy. Therefore, only thoracic cases that required a laminectomy were chosen to receive powdered vancomycin in this study.

The author acknowledges that a stronger scientific study would have involved randomizing the laminectomy patients into one group receiving and another group not receiving intraoperative powdered vancomycin. However, this created a moral dilemma. The author had already identified the laminectomy patients as being at increased risk for infection. Two other papers have demonstrated the efficacy of intraoperative powdered vancomycin in reducing the incidence of infection in patients undergoing posterior spinal surgery with the insertion of metal implants (8,9). It was, therefore, felt unjustifiable to deny any patient in the laminectomy group the proposed treatment. Instead, the author decided to examine whether the administration of intraoperative powdered vancomycin could eliminate the statistical difference in acute infection rates between the laminectomy and nonlaminectomy patients. The reduction of the acute infection rate in the laminectomy group and the elimination of the statistical difference in the infection rates between the laminectomy and nonlaminectomy groups demonstrate the power of the intraoperative administration of powdered vancomycin directly into the wound at the time of closure. Fortunately, the author’s infection rate (1.7%) prior to the use of powdered vancomycin was already too low to show a statistical difference from the infection rate after its use was adopted (1.8%).

The two infections in the prospective portion of this study occurred in a 61-year-old female and a 70-year-old male. Both had type 2 diabetes and BMIs of 41. Neither had a smoking history. Both patients received intravenous Cefazolin perioperatively and developed deep infections with methicillin resistant Staph aureus after implantation of thoracic paddle leads. They were the only two patients in this study who received nonrechargeable generators, which are roughly twice the size of the rechargeable generators that were used in the remaining patients. Consequently, a much larger subcutaneous pocket must be created. Although the retrospective practice study showed no association between infection and diabetic history or BMI, the author now applies powdered vancomycin intraoperatively in all diabetics with a BMI greater than 40 in addition to those patients requiring a laminectomy for implantation of the paddle lead. The nonrechargeable generator is no longer used in this practice.

Although the performance of a laminectomy proved to be associated with an increased risk of infection in the author’s practice, differences in technique and perioperative management may make other factors significant in other practices. It is therefore recommended that other surgeons consider examining their cases to determine which of their patients would benefit most from the use of intraoperative powdered vancomycin. No adverse effects were noted with this treatment.

**Authorship Statements**

Dr. Amrani conducted the research and composed the manuscript. Appropriate ethical approval of the final version was obtained.

### How to Cite this Article:


### REFERENCES

COMMENT

The author’s case series suggests that the use of Vancomycin powder, when included as part of a deliberate surgical routine, is a cost-effective strategy for minimizing the rate of post-implant infection. Careful statistical review of the author’s paddle electrode implants identified that the post-implantation infection rate was much higher in patients requiring a laminectomy, rather than laminotomy, approach for lead placement. In addition to the explanations posited by the author for the higher infection incidence with laminectomy, it is possible that longer operative time itself may contribute to increased risk of infection. It would be of interest to look at these cases and the incidence of infection not just by procedure, but also by the skin-to-skin operative time itself.

This series of patients undergoing implantation of paddle electrodes by a single surgeon demonstrates not only the possible benefit of powdered Vancomycin in preventing hardware infections, but also the importance of fastidious surgical technique, as evidenced by the implanter’s pre-protocol infection rate of 1.7%.

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Comments not included in the Early View version of this paper.