Clinical Study

Cost savings analysis of intrawound vancomycin powder in posterior spinal surgery

Osa Emohare, MBBS, PhD, Charles G. Ledonio, MD, Brian W. Hill, MD, Rick A. Davis, MD, David W. Polly, Jr., MD, Matthew M. Kang, MD

Department of Neurosurgery, Mail Stop 11503G, Regions Hospital, 640 Jackson Street, Saint Paul, MN 55101
Department of Orthopaedic Surgery, University of Minnesota, 2512 South 7th Street, Suite R200, Minneapolis, MN 55454
Department of Orthopaedic Surgery, Saint Louis University, 3635 Vista at Grand Blvd. St. Louis, Missouri 63104
Department of Orthopaedic Surgery, Mail Stop 11503L, Regions Hospital, 640 Jackson Street, Saint Paul, MN 55101

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Abstract

BACKGROUND CONTEXT: Recent studies have shown that prophylactic use of intrawound vancomycin in posterior instrumented spine surgery substantially decreases the incidence of wound infections requiring repeat surgery. Significant cost savings are thought to be associated with the use of vancomycin in this setting.

PURPOSE: To elucidate cost savings associated with the use of intrawound vancomycin in posterior spinal surgeries using a budget-impact model.

STUDY DESIGN: Retrospective cohort study.

PATIENT SAMPLE: Data from a cohort of 303 patients who underwent spinal surgery (instrumented and noninstrumented) over 2 years were analyzed; 96 of these patients received prophylactic intrawound vancomycin powder in addition to normal intravenous (IV) antibiotic prophylaxis, and 207 received just routine IV antibiotic prophylaxis. Patients requiring repeat surgical procedures for infection were identified, and the costs of these additional procedures were elucidated.

OUTCOME MEASURE: Cost associated with the additional procedure to remediate infection in the absence of vancomycin prophylaxis.

METHODS: We retrospectively reviewed the cost of return procedures for treatment of surgical site infection (SSI). The total reimbursement received by the health care facility was used to model the costs associated with repeat surgery, and this cost was compared with the cost of a single local application of vancomycin costing about $12.

RESULTS: Of the 96 patients in the treatment group, the return-to-surgery rate for SSI was 0. In the group without vancomycin, seven patients required a total of 14 procedures. The mean cost per episode of surgery, based on the reimbursement, the health care facility received was $40,992 (range, $14,459–$114,763). A total of $573,897 was spent on 3% of the 207-patient cohort that did not receive intrawound vancomycin, whereas a total of $1,152 ($12 × 96 patients) was spent on the cohort treated with vancomycin.

CONCLUSIONS: This study shows a reduction in SSIs requiring a return-to-surgery—with large cost savings—with use of intrawound vancomycin powder. In our study population, the cost savings totaled more than half a million dollars. © 2014 Elsevier Inc. All rights reserved.

Keywords: Local vancomycin powder; Vancomycin; Posterior spine surgery; Posterior spinal fusion; Infection; Cost saving; Economic; Cost-benefit analysis; Comparative effectiveness

FDA device/drug status: Not approved for this indication (vancomycin powder).

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* Corresponding author. Department of Neurosurgery, Mail Stop 11503G, Regions Hospital, 640 Jackson St, Saint Paul, MN 55101, USA.
Tel.: (651) 254-3684.
E-mail address: oemohare@umn.edu (O. Emohare)
Introduction

About 300,000 spinal surgeries are performed each year in the United States [1], with single cases costing, on average, $92,884 according to the DRG Summary for Medicare Inpatient Prospective Payment Hospitals, FY201 [2].

A major complication of spine surgery is postoperative surgical site infection (SSI) that can be devastating. Although the reported frequency and severity of these infections vary widely, with reported rates of 0.7% to 15% [3–13], the use of antibiotic prophylaxis is well established. The incidence of SSI has been noted to vary, depending on the procedure, with rates in short lumbar instrumentation as low as 2% to 4% [14–16] and as high as 8% to 15% in special situations, such as in trauma patients or those with cerebral palsy [13,14]. Not only does SSI cause additional morbidity and mortality, but health care resources must be expended to manage it [15,16].

Most SSIs after spine surgery are caused by Gram-positive organisms [17]. As a result, the use of intrawound vancomycin to prevent this complication is becoming more common. Recent publications have demonstrated a reduction in SSI with the use of intrawound vancomycin in posterior spine surgery, both in trauma patients [18,19] and in patients undergoing elective procedures [19,20]. The use of intrawound vancomycin in this setting achieves a high but well-localized tissue concentration of antibiotic and, given the size of the vancomycin molecule, there is very minimal ingress into the systemic circulation.

Although increased costs are known to be associated with SSI after spine surgery, and intrawound vancomycin is known to reduce the frequency of SSI, the potential budgetary impact of this reduction in SSI has yet to be elucidated. This study was designed to analyze the cost savings associated with the use of prophylactic intrawound vancomycin in posterior spine surgery.

Methods

After institutional review board approval, we enrolled consecutive patients between July 2010 and December 2012. Two surgeons participated in this study, each with a parallel group; patient allocation to a group was done simply on the basis of which patients were referred to a specific surgeon or on the basis of on-call admissions.

Over the recruitment period, one surgeon administered 1 g vancomycin powder (McKesson, San Francisco, USA) into the wounds of consecutive patients undergoing posterior spine surgery in addition to normal intravenous (IV) antibiotic prophylaxis that comprised IV cefazolin, in the case of a penicillin-allergic patient, vancomycin. The second surgeon continued the routine administration of prophylactic IV antibiotics without the instillation of vancomycin powder in the wounds. Vancomycin powder was instilled into all layers of the wound at the end of the procedure when the surgeon was ready to begin closing the incision. Although drains were routinely inserted, drained fluid was not examined for the presence or concentration of vancomycin. Timing of the drain removal was dictated by clinical imperative.

Most procedures consisted of fusions, discectomies, and lateral lumbar decompression. Procedures involving the thoracic, thoracolumbar, and lumbar spine were included, whereas the cervical spine was excluded. Also excluded were microdiscectomies and laminectomies (Table 1).

A multivariate analysis was performed to compare various parameters in the two parallel patient groups. The
approach to the computation of the budget impact analysis was based on guidelines issued by the International Society for Pharmacoeconomics and Outcomes Research (ISPOR) in the publication “Principles of good practice for budget impact analysis: report of the ISPOR Task Force on good research practices—budget impact analysis” [21]. In the budget impact analysis, patients were selected for inclusion if, after their initial posterior spine procedure, they were re-admitted emergently for at least one additional procedure (usually incision and drainage) to manage an infection
Table 2
Summary table for patients requiring repeat admission and procedures for deep infection after initial surgery

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Control group; mean±SD (%)</th>
<th>Treatment group; mean±SD (%)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>207</td>
<td>96</td>
<td>.0167</td>
</tr>
<tr>
<td>Age (y)</td>
<td>58.2±14.7</td>
<td>53.7±15.3</td>
<td></td>
</tr>
<tr>
<td>Sex, n (%)</td>
<td>Male 93 (45)</td>
<td>42 (44)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Female 114 (55)</td>
<td>54 (56)</td>
<td></td>
</tr>
<tr>
<td>Body mass index (Kg/m²)</td>
<td>29.85±6.15</td>
<td>29.77±5.9</td>
<td>.9303</td>
</tr>
<tr>
<td>Location, n (%)</td>
<td>Thoracic 7 (3)</td>
<td>11 (11)</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td></td>
<td>Thoracolumbar 18 (9)</td>
<td>22 (23)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lumbar 182 (88)</td>
<td>63 (66)</td>
<td></td>
</tr>
<tr>
<td>Previous surgery, n (%)</td>
<td>35 (17)</td>
<td>24 (25)</td>
<td>.0255</td>
</tr>
<tr>
<td>Tobacco use, n (%)</td>
<td>Yes 65 (31)</td>
<td>34 (35)</td>
<td>.6272</td>
</tr>
<tr>
<td></td>
<td>No 141 (68)</td>
<td>62 (65)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Unknown 1 (1)</td>
<td>0 (0)</td>
<td></td>
</tr>
<tr>
<td>Diabetes, n (%)</td>
<td>Yes 48 (23)</td>
<td>8 (8)</td>
<td>.0014</td>
</tr>
<tr>
<td></td>
<td>No 159 (77)</td>
<td>88 (92)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Unknown</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Procedure, n (%)</td>
<td>Lateral lumbar decompression 62 (30)</td>
<td>9 (9)</td>
<td>.0004</td>
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<tr>
<td></td>
<td>Fusion 122 (59)</td>
<td>78 (81)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Discectomy 16 (8)</td>
<td>8 (8)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other 7 (4)</td>
<td>1 (1)</td>
<td></td>
</tr>
<tr>
<td>Mean length of follow-up in mo</td>
<td>21.7±4.7</td>
<td>20.7±5.2</td>
<td>.0841</td>
</tr>
<tr>
<td>American Society of Anesthesiologists grade</td>
<td>2.38±0.6</td>
<td>2.4±0.7</td>
<td>.6862</td>
</tr>
<tr>
<td>Operative time (min)</td>
<td>182.7±106.5</td>
<td>257.3±117.3</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Blood loss (mL)</td>
<td>379.3±607.9</td>
<td>248.8±255.3</td>
<td>.0602</td>
</tr>
<tr>
<td>Superficial infection, n (%)</td>
<td>5 (2)</td>
<td>5 (5)</td>
<td>.2976</td>
</tr>
<tr>
<td>Deep infection, n (%)</td>
<td>7 (3)</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

SD, standard deviation.
Values in bold are those that reached statistical significance.

associated with the original procedure. This was a post hoc review, so factors determining the decision to reoperate were based on the clinical decision making of the surgeon responsible for care at the time rather than on a formal algorithm. Hospital costs associated with admission, the reimbursement received by the hospital, and the insurance adjustment were the only costs collected in the analysis; as such, the costs associated with implant and physician reimbursement were not included. Although it may be a very conservative estimate of the full costs associated with SSI, this approach is most easily reproducible by other investigators and health care facilities; this is because it avoids sensitivities of confidentiality clauses relating to the supply of implants and physician reimbursement, which may introduce a great degree of variability to the data. For each hospital admission that required drainage for the infection, we collected details for the total hospital charges previously outlined. We assumed that the acquisition cost of vancomycin was about $12 per dose, with negligible costs for administration because IV administration kits were not required. Patient-level cost data were obtained from Health-Partners Decision Support.

Results
A total of 303 patients were included in this study: 207 in the control group and 96 in the treatment group. A baseline multivariate analysis compared 12 variables in addition to the frequency of deep infections; six variables showed no differences between the two cohorts, whereas the remaining differences were evenly split between the treatment and control groups in terms of the direction of their significance (Table 2). Of the variables that differed between the groups, the control group had a marginally older population, a greater proportion of lumbar surgeries, and a higher proportion of diabetic patients, whereas the treatment group had a greater incidence of previous surgeries, greater frequency of instrumented fusions, and longer surgeries.

Using a very simple model, we demonstrated that additional hospital admissions for incision and drainage were associated with the nonuse of intrawound vancomycin and that a cohort of 207 patients who did not receive intrawound vancomycin generated $573,897.92 in additional costs (Table 3). For an acquisition cost of roughly $12 per patient, a comparable cohort of 96 patients generated no additional costs because there were no emergent admissions to treat SSI. The total outlay for a cohort of 150 patients to receive vancomycin was estimated at about $1,152 (Table 3).

Superficial infections developed in a total of 10 patients, five of which were in the treatment group and five of which were in the control group. Of the patients who did not receive prophylaxis, seven were readmitted on 14 separate occasions for procedures to manage deep infections (Table 3). Data indicate that payments to the hospital were typically less than the charge the hospital had generated. Charges generated by readmission to surgically treat SSI totaled $1,232,274.96, all of which was attributable to seven patients from the cohort who did not receive intrawound vancomycin; this value was more than double the reimbursement the hospital received: $573,897.92. Mean cost per episode was $88,019.64, whereas the mean reimbursement to the hospital was less than half of that: $40,992.71.

Of note, three of seven patients who required repeat admission after the initial surgery had more than one repeat admission. These three patients accounted for 10 of a total of 14 repeat admissions, whereas the remaining four patients accounted for one additional admission each. Costs associated with the three patients with multiple repeat admissions totaled $985,663.41, with an average cost per admission of $98,566.34, whereas respective reimbursement was $421,360.02 for the whole cohort and $42,136.00 per patient admission. Of note, total costs in the cohort requiring multiple admissions accounted for 80% of the overall readmission costs and 72% of overall reimbursement. These values suggest that multiple admissions after SSI
are a significant cost driver for patients who require treatment as a result of a lack of vancomycin prophylaxis.

Discussion

With ongoing health care reform focusing on both quality and cost of care, interventions that can reduce costs while maintaining quality of care provide the best value for health care expenditure. Simple, low-cost interventions that can be implemented with relative ease are a good approach toward achieving best value in the use of health care resources. The use of vancomycin to prevent SSI may be one such innovation.

Although several researchers have outlined the relative reductions in SSI from this approach to prophylaxis [18,20] and investigators often opine on costs potentially associated with SSI [18,22–24], this study is one of the first to document “real-world” costs associated with the management of SSI. The use of ISPOR guidelines in shaping the analysis [21] ensures that other investigators can readily perform similar assessments and, ultimately, compare their results with ours.

Although the size of the cohort in this study was relatively modest, it compares favorably with those of other studies evaluating the efficacy of intrawound vancomycin [14,18,19]. Also, given the numbers of spine procedures performed annually, our findings suggest that very significant savings may be achieved. It should be noted that, although significant, the cost savings we demonstrated underestimate the true cost because we limited input data to hospital costs, excluding the cost of replacement hardware and physician reimbursement. This approach ensured that the study can easily be replicated, although future studies can incorporate additional costs such as physician reimbursement and implants.

The spectrum of signs associated with SSI is such that we chose to limit our study to patients readmitted for the express purpose of treatment of SSI; although this may undercount the total number of SSI at the expense of less serious cases, the costs derived from patients with more severe diseases are clear.

Although the number of patients readmitted was relatively small, an interesting pattern in patients admitted on multiple occasions begins to emerge. These three patients seem to be the major cost driver for the whole model, representing just less than 1.5% of patients not treated with vancomycin and less than 50% of those readmitted; nonetheless, they account for 72% of reimbursement. This experience is clearly suboptimal for the patient because multiple emergent admissions may reduce their overall well being and cause financial hardship.

Although no formal time horizon was built into the model, the mean lengths of follow-up for the control and treatment groups were 21.7 and 20.7 months, respectively, which were sufficient to ensure that no further admissions relating to SSI occurred. In terms of loss to follow-up, it is possible that a patient subsequently presented to another hospital for follow-up in the broader group; in the group of patients that required multiple admissions for infection, present in-house records would indicate that the complications were managed at the host institution.

Potential criticisms of this study include the mixed population, exclusion of certain costs, and the lack of a time horizon. Although these criticisms may be valid, the simplicity of this study that stems from these assumptions enables this study to be easily replicated, which will ultimately improve the evidence base in this exciting area of spine research.

### Table 3
Multivariate analysis

<table>
<thead>
<tr>
<th>Patient</th>
<th>Initial diagnosis</th>
<th>Original procedure</th>
<th>Subsequent procedure</th>
<th>Patient type</th>
<th>Total charges (USD)</th>
<th>Total insurance payments</th>
<th>Total insurance adjustments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>L3–S1 stenosis/L4–L5 spondylolisthesis</td>
<td>Fusion</td>
<td>1+D</td>
<td>Inpatient</td>
<td>205,904.60</td>
<td>23,647.16</td>
<td>182,257.44</td>
</tr>
<tr>
<td>2</td>
<td>L4–L5 spondylolisthesis</td>
<td>Fusion</td>
<td>1+D</td>
<td>Inpatient</td>
<td>53,505.83</td>
<td>37,166.13</td>
<td>16,339.70</td>
</tr>
<tr>
<td>3</td>
<td>Lumbar spondylolisthesis/degenerative scoliosis</td>
<td>Fusion</td>
<td>1+D</td>
<td>Inpatient</td>
<td>67,692.70</td>
<td>36,489.59</td>
<td>31,203.11</td>
</tr>
<tr>
<td>4</td>
<td>L4–L5 stenosis/L4–L5 spondylolisthesis</td>
<td>LLD/fusion</td>
<td>1+D</td>
<td>Inpatient</td>
<td>62,165.12</td>
<td>41,251.50</td>
<td>20,913.62</td>
</tr>
<tr>
<td>5</td>
<td>L5–S1 herniated disc</td>
<td>LLD</td>
<td>1+D (bedside)</td>
<td>Inpatient</td>
<td>31,226.09</td>
<td>26,011.34</td>
<td>5,214.75</td>
</tr>
<tr>
<td>6</td>
<td>L3–L5 herniated nucleus pulposus</td>
<td>LLD</td>
<td>1+D</td>
<td>Inpatient</td>
<td>44,863.10</td>
<td>8,265.38</td>
<td>36,597.72</td>
</tr>
<tr>
<td>7</td>
<td>L3–L5 stenosis</td>
<td>LLD</td>
<td>1+D</td>
<td>Inpatient</td>
<td>38,497.90</td>
<td>37,950.05</td>
<td>547.85</td>
</tr>
</tbody>
</table>

Note: Cost table for patients requiring readmission and drainage after surgical site infection.

1+D, incision and drainage; LLD, lateral lumbar decompression; USD, United States Dollars; SD, standard deviation.
addition, despite some differences in population and approach, significant overlap, in terms of our findings, seem to exist between this study and a recently published economic analysis evaluating the same topic [25].

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References


