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Progress not panacea: vancomycin powder efficacy and dose evaluated in an in vivo mouse model of spine implant infection

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Abstract

Background: Intrawound vancomycin powder (VP) has been rapidly adopted in spine surgery with apparent benefit demonstrated in limited, retrospective studies. Randomized trials, basic science, and dose response studies are scarce.

Purpose: This study aims to test the efficacy and dose effect of VP over an extended time course within a randomized, controlled in vivo animal experiment.

Study design/setting: Randomized controlled experiment utilizing a mouse model of spine implant infection with treatment groups receiving vancomycin powder following bacterial inoculation.

Methods: Utilizing a mouse model of spine implant infection with bioluminescent Staphylococcus aureus, 24 mice were randomized into 3 groups: 10 infected mice with VP treatment (+VP), 10 infected mice without VP treatment (No-VP), and 4 sterile controls (SC). Four milligrams of VP (mouse equivalent of 1 g in a human) were administered before wound closure. Bioluminescence imaging was performed over 5 weeks to quantify bacterial burden. Electron microscopy (EM), bacterial colonization assays (Live/Dead) staining, and colony forming units (CFU) analyses were completed. A second dosing experiment was completed with 34 mice randomized into 4 groups: control, 2 mg, 4 mg, and 8 mg groups.

Results: The (+VP) treatment group exhibited significantly lower bacterial loads compared to the control (No-VP) group, ($p<.001$). CFU analysis at the conclusion of the experiment revealed 20% of mice in the +VP group and 67% of mice in the No-VP group had persistent infections, and the (+VP) treatment group had significantly less mean number of CFUs ($p<.03$). EM and Live/Dead staining revealed florid biofilm formation in the No-VP group. Bioluminescence was suppressed in all VP doses tested compared with sterile controls ($p<.001$). CFU analysis revealed a 40%, 10%, and 20% persistent infection rate in the 2 mg, 4 mg, and 8 mg dose groups, respectively. CFU counts across dosing groups were not statistically different ($p=.56$).

Conclusions: Vancomycin powder provided an overall infection prevention benefit but failed to eradicate infection in all mice. Furthermore, the dose when halved also demonstrated an overall protective benefit, albeit at a lower rate.

Clinical significance: Vancomycin powder is efficacious but should not be viewed as a panacea for perioperative infection prevention. Dose alterations can be considered, especially in patients with kidney disease or at high risk for seroma.

Keywords: Biofilm; Infection; Surgical site infection; Vancomycin powder.