Investigating the effect of antiseptic solutions on removal of biofilm in the setting of an acute periprosthetic joint infection using a mouse model

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Disclosures: C.A. Chao: None. M. Hammad: None. K. Bell: None. M. Bostrom: 1; Smith and Nephew. 3B; Smith and Nephew. 6; Ines Mandl Research Foundation, Smith and Nephew. 8; Journal of Orthopaedic Research. 9; American Austrian Foundation, Hip Society. A. Carli: 3B; Heraeus Medical

INTRODUCTION: Periprosthetic joint infection (PJI) remains to be a significant complication following arthroplasty surgery. Currently, two-stage revision is recognized as a golden standard for treating PJIs, but the procedure requires multiple surgeries over a considerable time interval leaving a significant economic burden and morbidity to the patients [1, 2]. On the other hand, a procedure with implant retention (debridement, antibiotics, and implant retention: DAIR) may provide a substantial benefit to the patient if the operation is successful [3]. However, DAIR surgery yields a low success rate, and the indication for surgery is limited to the patient with low virulence infection and in the acute phase [2]. The poor outcome of DAIR is largely attributed to the matured bacterial biofilm adhering to the prosthesis and surrounding tissue which is resistant to mechanical cleansing [4]. One potential method to remove bacterial biofilm would be using anti-bacterial irrigation solutions. While the efficacy of high concentration anti-bacterial irrigation solution (povidone-iodine) has been validated in in-vitro studies, the question remains on whether these methods would have similar anti-bacterial effects in actual arthroplasty surgery [5]. Therefore, the purpose of the current study is to develop a reproducible animal model for DAIR surgery and to validate the effect of anti-bacterial irrigation solutions combined with DAIR surgery in treating PJI.

METHODS: MSSA (Xen36) S. aureus PJI was induced in ten mice using a previously validated in vivo murine model of PJI. The placement of the tibial implant was confirmed with X-ray imaging, and mice were permitted to weight bear as tolerated. Seven days following tibial implantation and inoculation, the mice received DAIR surgery. The DAIR procedure involved six minutes of debridement of the infected tissue and three-minute treatment with an irrigation solution. Of the ten mice in this pilot group, five were randomized to control mice, and were treated with sterile saline during the irrigation step. The remaining mice were experimental mice and were treated with a 1:1 ratio of undiluted (10%) povidone iodine and 3% hydrogen peroxide. Mice were immediately euthanized following the DAIR procedure. Bacterial burden was quantified in the periprosthetic soft tissue, on the tibia, and on the implant via ex vivo counting of colony forming units.

RESULTS SECTION: The most pronounced reduction in bacterial load was observed with the implant, where the control group (PBS-treated) averaged 1.69×10^6 CFUs/mL, while the HP/PI group averaged 1.21×10^4 CFUs/mL, representing a 99.3% decrease. In the bone, a similar but slightly smaller reduction was seen, with 6.44×10^4 CFUs/mL in controls versus 4.75×10^3 CFUs/mL in the HP/PI group - a 92.6% decrease. In contrast, the effect on soft tissue was less dramatic, decreasing from 2.3×10^6 CFUs/mL in controls to 1.18×10^6 CFUs/mL in treated mice, representing a 48.9% reduction.

DISCUSSION: Irrigating with a 1:1 ratio of undiluted (10%) povidone iodine and 3% hydrogen peroxide led to large bacterial reductions to the bone and implant bacterial burden and are promising early results in the pilot study. Continued studies involving the addition of antibiotics, and more animals are needed to validate the effect of anti-bacterial irrigation solutions combined with DAIR surgery in treating PJI.

SIGNIFICANCE/CLINICAL RELEVANCE: The purpose of the current study is to develop a reproducible in-vivo animal model for DAIR surgery and to investigate the efficacy of DAIR surgery with anti-bacterial irrigation solution. If these solutions can decrease the bacterial burden in DAIR surgery, it could dramatically change the existing treatment paradigm for PJIs.

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