Povidone-iodine and Silver Nitrate are Equally Effective in Eradicating Staphylococcal Biofilm Grown on a Titanium Surface: An in vitro Analysis

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INTRODUCTION:

The gold standard for treatment of acute periprosthetic joint infection (PJI) is debridement, irrigation, and implant retention (DAIR). However, the success of this procedure is variable, ranging from 10% to 95% depending on numerous factors, including the clinical status of the host, the type of offending organism, and the way the DAIR protocol is applied, which in many cases is performed in a non-standardized fashion. The presence of biofilm onto the implant makes irrigation with an antibacterial solution a key component to the success of DAIR. However, very few studies have compared the effectiveness of commonly used irrigation solutions on the eradication of biofilm grown on clinically relevant orthopaedic materials. The purpose of this study was to compare the efficacy of five distinct antiseptic solutions in eradicating Staphylococcal biofilm embedded in mature biofilm on a titanium surface.

METHODS:

6538-Methicillin-sensitive *Staphylococcus aureus* (MSSA) and 43300-methicillin-resistant *Staphylococcus aureus*(MRSA) ATCC standard strains were grown over porous Ti-6Al-4V acetabular screw-caps (G7, Zimmer-Biomet). Antibacterial solutions were povidone-iodine, rifampicin, silver nitrate, copper sulphate, chlorhexidine; for which the minimum inhibitory concentration and the minimum biofilm eradication concentration (MBEC) were determined per bacterial strain. The latter values were selected per each diluted solution separately to define the most effective concentration to perform the irrigation. MBEC values for MSSA and MRSA, respectively, were as follows: 8000 ug/ml and 16000 ug/ml for povidone-iodine; 64 ug/ml and 128 ug/ml for rifampicin; 10000 ug/ml and 5120 ug/ml for silver nitrate; 900 ug/ml and 900 ug/ml for copper sulphate; 16 ug/ml and 32 ug/ml for chlorhexidine. Following 24 hours of bacterial proliferation and biofilm formation, titanium screw-caps were exposed to 3 minutes with each solution. After an initial washing step, bacterial separation from the surface of each specimen was done with two methods, vortex agitation and footprint on agar plate, in triplicate. The colony-forming units (CFU) were counted to determine the number of viable adherent bacteria before and after agitation and the difference (delta) of CFU/ml was calculated for each irrigation solution. CFU values were divided into categories based on the number of logs rescued after washing. A three-fold log reduction in CFU counts was considered as a measure of solution efficacy. Comparison between groups was made with Fisher's test.

RESULTS:

Rifampicin, copper sulphate and chlorhexidine solutions were ineffective against MSSA and MRSA biofilm compared to povidone-iodine ($p<0.01$) and silver nitrate ($p=0.015$) that had a delta CFU of 8 log. There was no significant difference in final concentration between povidone-iodine and silver nitrate ($p>0.05$). In regards to the footprint method performed after washing, only povidone-iodine and silver nitrate showed negative footprints without visible bacteria, unlike the rest of the substances that were positive in three tests both for the MSSA ($p=0.005$) and MRSA ($p=0.014$).

DISCUSSION AND CONCLUSION: Povidone-iodine and silver nitrate were the only irrigating solutions capable of eradicating at least 99% of 24-hour-biofilm on titanium discs. The concentration of betadine necessary to eradicate 99% of biofilm (0.8-1.6%) seems to be higher than the suggested prophylactic 0.3% concentration.