Evaluating Soaking Duration: Ex Vivo vs In Vitro Comparison for Determining the Efficacy of Dilute Povidone-Iodine Irrigation Solution

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INTRODUCTION:

Antimicrobial irrigation solutions are essential for infection prevention, with povidone-iodine (PVP-I) being widely used due to its reported broad-spectrum activity. Evaluation of irrigation solutions are largely done in vitro, however, biochemical conditions affect both bacterial metabolism and antimicrobials. For example, in the food industry, unsaturated fat content is measured by its level of iodine consumption. Saturated fat is populated with hydrogen while unsaturated fat has double bonds that attract halogens such as iodine. Fatty acids and the like exist in the human body and are not represented during in vitro testing of irrigation fluids. This study compares an ex vivo human bone organ culture methodology to a typical in vitro method for determining the optimal soaking duration of PVP-I (Surgiphor) against Gram-positive and negative bacteria.

METHODS:

Viable human femoral heads were collected during total hip arthroplasty from which 84 trabecular bone cores were harvested. Half of the cores were inoculated with MRSA and the remaining with E. coli for 2-hours in media that replicates human serum. Groups of seven were then exposed to PVP-I for 0.5, 2, and 3 minutes with patient matched saline controls. The cores were neutralized in Dey-Engley broth after exposure to PVP-I and sonicated for CFU counting. In vitro, 24-well plates were inoculated in tryptic broth and processed in a similar manner. Iodine consumption of bone lipid extract was also measured per ASTM D5768-02.

RESULTS:

The MRSA in vitro group extraordinarily reduced by log 6.2 \pm 0.2 (3min), 3.1 \pm 0.2 (2min), and 2.3 \pm 0.5 (0.5min)(P<0.001). This was significantly more than every ex vivo group time point (P<0.001–P=0.003)(Figure 1). Ex vivo groups had no differences among themselves (P=0.358–p=0.771). The Gram-negative in vitro E. coli group reduced by log 7.9 \pm 0.6 (3min), log 1.6 \pm 0.2 (2min), and log 1.1 \pm 0.4 (0.5min). Ex vivo comparisons were similar, with significant differences between the 3-minute in vitro group (P<0.001) but not among shorter exposures (P=0.106–P=0.912)(Figure 2). lodine titrations per ASTM standards indicated 0.28g iodine consumption per gram of bone extract. DISCUSSION AND CONCLUSION:

This study reveals significant differences in the efficacy of povidone-iodine (PVP-I) when employing ex vivo and in vitro methodologies. The lipid-rich ex vivo environment, which more accurately reflects clinical conditions, consumes iodine, thus diminishing the antimicrobial properties of the currently available dilute betadine. Based on these findings, we strongly recommend that surgeons extend the duration of dilute betadine irrigation to at least three minutes. This adjustment is crucial to achieve a meaningful log reduction and effectively eliminate contamination at the conclusion of the procedures.





Figure 1. Graph showing MRSA reductions using ex vivo verses in vitro soaking durations methods.

Figure 2. Graph showing E. coli reductions using ex vivo verses in vitro soaking durations methods .