Optimal Diluted Povidone-Iodine Solution for Preventing Periprosthetic Joint Infection

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INTRODUCTION: Periprosthetic joint infection (PJI) is a serious and challenging complication following joint arthroplasty, leading to significant morbidity and healthcare costs. Effective intraoperative strategies to prevent PJI are crucial for improving patient outcomes. Povidone-iodine (PVP-I) is widely recognized for its broad-spectrum antimicrobial properties and has been used in various concentrations for surgical irrigation. However, the optimal concentration and irrigation timing for maximizing the preventive efficacy of PVP-I against PJI remain unclear. Previous studies have shown varying results, and there is a lack of consensus on standardized protocols. This study aims to determine the most effective concentration and irrigation interval of diluted PVP-I solution to prevent PJI using a rat femur model inoculated with methicillin-sensitive Staphylococcus aureus (MSSA).

METHODS:

To establish a reliable PJI model, we used adult male Sprague-Dawley rats, weighing 250-300 grams. All procedures were conducted under aseptic conditions in a dedicated animal surgery suite. Rats were anesthetized using isoflurane, and a longitudinal incision was made along the lateral aspect of the femur. A stainless steel plate was affixed to the femur using screws to simulate a prosthetic implant. The wound was then inoculated with a 10^8 CFU/ml suspension of methicillin-sensitive Staphylococcus aureus (MSSA) to induce infection.

After inoculation, the rats were randomly assigned to one of three groups based on the irrigation solution used: Group A (saline), Group B (0.13% PVP-I), and Group C (0.35% PVP-I). Each group was further divided into two subgroups based on irrigation timing intervals: 30 minutes and 60 minutes. The irrigation procedure involved immersing the surgical site in the assigned solution for 3 minutes at the specified intervals. The incisions were then closed with sutures.

Postoperatively, rats were monitored daily for signs of infection and changes in body weight, an indicator of systemic infection response. On postoperative day 7, rats were euthanized, and the femurs and plates were harvested. The implants were sonicated in phosphate-buffered saline to dislodge biofilm bacteria. The resulting suspension was serially diluted and plated on agar to quantify bacterial colony-forming units (CFU).

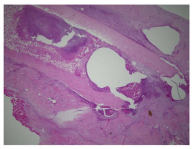
To assess the impact of infection and treatment on bone integrity, μ-CT scans were performed on the harvested femurs to measure cortical bone volume. The extent of bone destruction was quantified by comparing the bone volume of infected femurs to that of non-infected controls. Histopathological analysis of the femurs was performed using hematoxylin and eosin (H&E) staining to evaluate the presence of inflammatory cells, abscess formation, and osteoid production.

Results: Body weight recovery was fastest in Group C with 30-minute intervals. CFU assay results showed bacterial counts of $36.0\pm4.0\times10^6$ CFU/ml in Group A, $20.0\pm4.0\times10^4$ CFU/ml in Group B, and $11.0\pm5.0\times10^3$ CFU/ml in Group C for 60-minute intervals. For 30-minute intervals, counts were $20.0\pm4.5\times10^6$ CFU/ml in Group A, 66.0 ± 20.0 CFU/ml in Group B, and no bacteria detected in Group C. Shorter intervals and higher PVP-I concentrations significantly reduced bacteria ($P<0.05$). Cortical bone volumes were $0.13cm^3$ (Group A), $0.16cm^3$ (Group B), and $0.15cm^3$ (Group C) for 60-minute intervals, and $0.15cm^3$ (Group A), $0.17cm^3$ (Group B), and $0.16cm^3$ (Group C) for 30-minute intervals. Significant differences in bone volume were observed between 30 and 60-minute intervals across all groups ($P<0.05$), but not between Groups B and C ($P=0.33, 0.98$). Histopathologically, Group A exhibited abscesses and bone destruction, while Groups B and C with 30-minute intervals showed osteoid formation.

RESULTS: The findings of this study underscore the importance of both the concentration and frequency of PVP-I irrigation in preventing PJI. The significant reduction in bacterial counts and preservation of bone volume with 0.35% PVP-I used every 30 minutes highlights its efficacy. The absence of bacteria in Group C with 30-minute intervals indicates that frequent irrigation can effectively manage bacterial load during surgery. Furthermore, histopathological results showing osteoid formation in Groups B and C with frequent irrigation suggest better bone healing and less inflammatory response compared to saline irrigation. These results suggest that a higher concentration of PVP-I, coupled with more frequent irrigation, may offer superior outcomes in preventing infections and promoting bone health in surgical settings.

DISCUSSION AND CONCLUSION: This study suggests that using 0.35% PVP-I solution at 30-minute intervals is the optimal protocol for PJI prevention. Both the addition of PVP-I and irrigation frequency are critical factors for effective intraoperative decontamination.

Saline 60min



0.35% Iodine 30min