Beyond The 5 Second Rule: What To Do With Drop-Contaminated Bone?

Chad A. Krueger, MD;1 Brendan D. Masini, MD;1 Joseph R. Hsu, MD;2 Joseph C. Wenke, PhD;2 Daniel J. Stinner, MD;1 and the Skeletal Trauma Research Consortium (STReC)

1Brooke Army Medical Center, Ft. Sam Houston, TX
2United States Army Institute of Surgical Research, Ft. Sam Houston, TX
Disclaimer and Disclosure

- The opinions or assertions contained herein are the private views of the authors and are not to be construed as official or reflecting the views of the Department of the Army, Department of Defense or the US government. This work was prepared as part of their official duties and, as such, there is no copyright to be transferred.

- None of the authors have any financial disclosures
- Our institution receives research funds from the Geneva Foundation
  - None of those funds were used specifically for this project
Introduction

• Gross contamination of critical bone segments can be devastating
• Devascularized bone segments easily infected
• What to do with dropped-contaminated bone?

Introduction

• Lack of conclusive evidence
  – Ethylene oxide gas
  – Gamma irradiation
  – Heated normal saline
    Schultke E et al. An easy and safe method to store and disinfect explanted skull bone. *Acta Neurochir (Wien)* 1999;141:525-528
  – Autoclave
  – Antibiotic soaks
Introduction

• Povidone-iodine soaks


– Recent support


• Cell viability vs Effectiveness
Introduction

• Chlorhexidine
  – 4% chlorhexidine for 10 minutes followed by Antibiotic soak for 40 min
  

  – 30 mins of 4% Chlorhexidine, triple antibiotic soak
  

  – 5 basins of 4% chlorhexidine 15 min each then 4% chlorhexidine 2 hrs
  

  – 4% chlorhexidine for 90 seconds
  
Purpose

• Describe temporal relationship between bacteria on grossly contaminated bone segments and chlorhexidine soak time

• Provide evidence for appropriate soak time
Methods

• 54 porcine diaphyseal bone segments
• Each segment dropped onto Agar plate
  – Agar plate contained bioluminescent *Staphylococcus aureus*
  – Retrieved after 5 seconds
Methods

- Baseline imaging obtained
Methods

• Imaging
  – Camera detects photons emitted from *S. aureus*
  – Directly correlates to bacteria amount
Methods
Methods

- 3 groups of soaks
  - Normal Saline (NS)
  - 2% Chlorhexidine (2&Chl)
  - 4% Chlorhexidine (4%Chl)
- 18 bone segments in each group
Methods

• Segments reimaged at set intervals
  – 5 minutes
  – 10 minutes
  – 20 minutes
  – 30 minutes
  – 60 minutes
## Results

<table>
<thead>
<tr>
<th>Time (min)</th>
<th>NS</th>
<th>2%Chl</th>
<th>4%Chl</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>2.18E+07</td>
<td>2.31E+07</td>
<td>2.00E+07</td>
</tr>
<tr>
<td>5</td>
<td>3.34E+07</td>
<td>1.45E+06</td>
<td>6.62E+05</td>
</tr>
<tr>
<td>10</td>
<td>2.96E+07</td>
<td>3.43E+05</td>
<td>2.72E+05</td>
</tr>
<tr>
<td>20</td>
<td>1.92E+07</td>
<td>1.31E+05</td>
<td>7.78E+04</td>
</tr>
<tr>
<td>30</td>
<td>1.27E+07</td>
<td>6.73E+04</td>
<td>3.83E+04</td>
</tr>
<tr>
<td>60</td>
<td>6.21E+06</td>
<td>3.44E+04</td>
<td>2.08E+04</td>
</tr>
</tbody>
</table>
Results

- NS
- 2% CHL
- 4% CHL

Time (minutes)
### Results

#### Average Percent Decrease in *Staphylococcus aureus* (lux)

<table>
<thead>
<tr>
<th>Time (min)</th>
<th>Group 1 (NS)</th>
<th>Group 2 (2%CHL)</th>
<th>Group 3 (4%CHL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>0.00%</td>
<td>93.09%</td>
<td>94.32%</td>
</tr>
<tr>
<td>10</td>
<td>0.00%</td>
<td>98.16%</td>
<td>97.60%</td>
</tr>
<tr>
<td>20</td>
<td>0.00%</td>
<td>99.31%</td>
<td>99.26%</td>
</tr>
<tr>
<td>30</td>
<td>29.84%</td>
<td>99.63%</td>
<td>99.63%</td>
</tr>
<tr>
<td>60</td>
<td>72.23%</td>
<td>99.81%</td>
<td>99.82%</td>
</tr>
</tbody>
</table>
Results

• At all time points
  – Significant difference
    • 2% and 4% chlorhexidine vs normal saline
    • P<0.0001
  – No difference between 2% and 4% chlorhexidine
    • P<0.9984
Discussion

- 20 minutes in 2% or 4% chlorhexidine
  - 99% bacterial decrease
    - Actual decrease in bacterial count
    - Not reliant on cultures
  - Increased costs with prolonged soaks
  - Detrimental effects of chlorhexidine on tissue


Limitations

- Cell viability
- External validity
  - In vitro
  - *S. aureus* only
- Heterogeneity of *S. aureus* on Agar plates
  - Repeated images of same area
Summary

- Grossly contaminated bone segments can be effectively cleansed of *S. aureus* by a soak in 2% chlorhexidine for 20 minutes.