Battlefield Medicine:
The American Response to Gas Gangrene on the Western Front

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Introduction

“No other disease that falls to the lot of the surgeon places so heavy a burden on his judgment nor is so dependent upon his management as this dread condition.”

It was found the infection complicated 1% of open wounds and 6% of open fractures.
Introduction

X-ray: Gas bubbles in the wound
Introduction

This presentation examines six topics:

• Incidence
• Etiology
• Pathology
• Clinical Picture
• Prophylaxis
• Prognosis

Western Front battlefield in 1917
Incidence
How many American soldiers had gas gangrene infections in World War I?

Evidence of why gas gangrene earned its lethal reputation
Incidence
How many American soldiers had gas gangrene infections in World War I?

Operating room and surgical team of Evaluation Hospital No. 8, 1918
Incidence
How many American soldiers had gas gangrene infections in World War I?

<table>
<thead>
<tr>
<th>Part of body</th>
<th>Total number</th>
<th>For severity of injury</th>
<th>For simple infection</th>
<th>For gas gangrene</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number</td>
<td>Per cent</td>
<td>Number</td>
<td>Per cent</td>
</tr>
<tr>
<td>Arms</td>
<td>31</td>
<td>9</td>
<td>29.0</td>
<td>1</td>
</tr>
<tr>
<td>Forearms</td>
<td>16</td>
<td>11</td>
<td>68.7</td>
<td>1</td>
</tr>
<tr>
<td>Fingers</td>
<td>44</td>
<td>32</td>
<td>95.6</td>
<td>1</td>
</tr>
<tr>
<td>Thighs</td>
<td>60</td>
<td>5</td>
<td>8.33</td>
<td>10</td>
</tr>
<tr>
<td>Legs</td>
<td>38</td>
<td>12</td>
<td>31.5</td>
<td>4</td>
</tr>
<tr>
<td>Feet</td>
<td>6</td>
<td>4</td>
<td>66.6</td>
<td>0</td>
</tr>
<tr>
<td>Toes</td>
<td>11</td>
<td>10</td>
<td>90.9</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>206</td>
<td>93</td>
<td>45.1</td>
<td>17</td>
</tr>
</tbody>
</table>

During this period the total number of deaths was 363. These deaths were due to the following causes:

<table>
<thead>
<tr>
<th>Cause of death</th>
<th>Number</th>
<th>Per cent</th>
<th>Cause of death</th>
<th>Number</th>
<th>Per cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas gangrene</td>
<td>81</td>
<td>17.0</td>
<td>Head injuries</td>
<td>80</td>
<td>14.0</td>
</tr>
<tr>
<td>Simple infection</td>
<td>7</td>
<td>2.0</td>
<td>Spinal injuries</td>
<td>12</td>
<td>3.3</td>
</tr>
<tr>
<td>Shock and hemorrhage</td>
<td>88</td>
<td>24.2</td>
<td>Multiple wounds</td>
<td>30</td>
<td>8.3</td>
</tr>
<tr>
<td>Chest wounds</td>
<td>63</td>
<td>15.0</td>
<td>Pneumonia</td>
<td>9</td>
<td>2.5</td>
</tr>
<tr>
<td>Abdominal wounds</td>
<td>47</td>
<td>10.2</td>
<td>Poison gas</td>
<td>6</td>
<td>2.0</td>
</tr>
</tbody>
</table>
**Incidence**

How many American soldiers had gas gangrene infections in World War I?

<table>
<thead>
<tr>
<th>Time interval between injury and operation</th>
<th>With gangrene</th>
<th>Without gangrene</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Received at hospital between</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 to 6 hours</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>6 to 12 hours</td>
<td>12</td>
<td>80</td>
<td>92</td>
</tr>
<tr>
<td>12 to 18 hours</td>
<td>15</td>
<td>90</td>
<td>105</td>
</tr>
<tr>
<td>18 to 24 hours</td>
<td>27</td>
<td>55</td>
<td>82</td>
</tr>
<tr>
<td>24 to 36 hours</td>
<td>30</td>
<td>56</td>
<td>86</td>
</tr>
<tr>
<td>36 to 48 hours</td>
<td>20</td>
<td>17</td>
<td>37</td>
</tr>
<tr>
<td>48 to 60 hours</td>
<td>23</td>
<td>23</td>
<td>46</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Time interval between injury and operation</th>
<th>With gangrene</th>
<th>Without gangrene</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Received at hospital between—Continued.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>60 to 72 hours</td>
<td>9</td>
<td>9</td>
<td>18</td>
</tr>
<tr>
<td>72 to 96 hours</td>
<td>9</td>
<td>10</td>
<td>19</td>
</tr>
<tr>
<td>96 to 120 hours</td>
<td>11</td>
<td>7</td>
<td>18</td>
</tr>
<tr>
<td>120 plus</td>
<td>6</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>Total</td>
<td>162</td>
<td>349</td>
<td>511</td>
</tr>
</tbody>
</table>
Etiology
What was the cause of gas gangrene in World War I?

X-Rays: Numerous foreign bodies, fractures and evidence of gas gangrene
Etiology
What was the cause of gas gangrene in World War I?

Muscle fibers showing Gram-positive and negative rods and Gram-positive cocci
Etiology
What was the cause of gas gangrene in World War I?

Weinberg and Seguin: 1917 study of 91 patients found:

- 11 different types of bacteria
- 10 had a single variety
- 14 had several varieties
- 67 had anaerobic and aerobic bacteria

The most frequent bacteria were:

- B. welchii-77%
- B. oedematiens-34%
- B. sporogenes-27%
- Vibrion septique-17%

Necrotic muscle fibers
Etiology
What was the cause of gas gangrene in World War I?

Treatment at an American Dressing Station, Lahayville France, 1918
Pathology
What were the effects from a gas gangrene infection in World War I?

X-ray: Gas around point of fracture

Toxic edema at the wound track
Pathology
What were the effects from a gas gangrene infection in World War I?

Bronzing of skin in avirulent Gas Gangrene

Contemporary image of coalescing vesicles
Pathogenesis of Gas Gangrene

1. Penetrating Wound
   Entry point of anaerobes

2. Multiplication

3. Toxin Production

4. Gas Gangrene
   Muscle necrosis

Pathology
What were the effects from a gas gangrene infection in World War I?
Pathology
What were the effects from a gas gangrene infection in World War I?

Alexander Fleming’s 1915 bacteriology of septic wounds for 137 patients
Clinical Picture
What was the clinical picture for a gas gangrene infection in World War I?

Unloading wounded at Field Hospital No. 28, Varennes, October 2, 1918
Clinical Picture
What was the clinical picture for a gas gangrene infection in World War I?

Deep portion of wound with bacteria

Contemporary image of gas gangrene
Clinical Picture
What was the clinical picture for a gas gangrene infection in World War I?

French Autochrome taken by Emile Chautemps
Prophylaxis
What were the measures taken to prevent gas gangrene infections in World War I?

Three techniques: Surgical Excision, Antibacterial Solution, Polyvalent Serum
Prophylaxis

What were the measures taken to prevent gas gangrene infections in World War I?

Excision of the external wound, of the aponeurotic layer, of injured muscles
Prophylaxis

What were the measures taken to prevent gas gangrene infections in World War I?

Operating room and surgical team of Evaluation Hospital No. 8, 1918
Prophylaxis
What were the measures taken to prevent gas gangrene infections in World War I?

Progressive stages of treatment and evacuation on the battlefield
Prophylaxis

What were the measures taken to prevent gas gangrene infections in World War I?

American response to prevent gas gangrene:

- Debridement
- Irrigation of the wound with a chemical antiseptic
- Bacteriological analysis

X-ray: bone fractures with foreign bodies
Prophylaxis

What were the measures taken to prevent gas gangrene infections in World War I?

Carrel's delivery system for Dakin’s sodium hypochlorite solution

Dr. Alexis Carrel
Prophylaxis
What were the measures taken to prevent gas gangrene infections in World War I?

Major William Keen’s The Treatment of War Wounds
Prophylaxis

What were the measures taken to prevent gas gangrene infections in World War I?

Polyvalent Serum

Dr. Frances Ivens
Prognosis
What was likelihood of an American soldier surviving a gas gangrene infection?

Adjusting splint on a litter patient, Broussey France, April 20, 1918