Amputation-Sparing Treatment by Nature: “Surgical” Maggots Revisited

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Maggots were used as adjunct treatment for infected wounds that showed no response to the classical approach of wound debridement and antibiotic therapy. We summarize findings for 11 patients with necrotic wounds who received treatment with “surgical” maggots (100–2900 applied in 3–10 changes of dressing) for 11–34 days, which apparently aided in tissue remodeling and cure, and describe 2 typical patients in detail.

In these times of high-tech medicine, it can still be efficacious to resort to basic principles that have evolved in nature and that may help the physician combat specific medical problems [1–3]. For instance, traumatic wounds that fail to heal because of recurrent infections and underlying pathology, such as vascular insufficiency or diabetes mellitus, often leave physicians no choice but to resect the affected tissue. For minor wounds, this will not compromise the patient’s quality of life, but for larger wounds on the extremities, as often occur in patients with vascular insufficiency or diabetes mellitus, amputation of part of a limb can be the only option. In selected cases, use of natural removers of necrotic and infected tissue—maggots (sterile larvae of Lucilia sericata)—may result in adequate wound healing and prevent the need to amputate a limb [4, 5]. In the past 3 years, we have applied sterile maggots to help remove infected necrotic tissue in 11 selected patients. We describe 2 of these patients in detail.

Case history 1. A 16-year-old male patient was admitted to an intensive care unit because of meningococcal sepsis. The diagnosis was made on the basis of culture of skin biopsy samples, which yielded Neisseria meningitides serogroup C. The patient received intravenous treatment with ceftriaxone in combination with gentamicin and rifampicin; after a few days, therapy was changed to benzylpenicillin G, 12 × 106 U iv per day. The patient survived the acute episode of meningococcal sepsis but developed infectious necrosis of the extremities of the hands and feet (figure 1). The patient was transferred to the trauma unit of our institution (Leiden University Medical Center, Leiden, The Netherlands); at admission, he was still febrile. Open partial borderline amputation of all middle phalanges of the second through the fifth fingers of the left and right hands and a resection of the distal phalanx of the left and right thumbs were done. In addition, Syme’s amputation (amputation at the level of the ankle joint) of the right foot was done, as well as extensive soft-tissue debridement of the left foot.

Empirical treatment with flucloxacinil, 1 g iv 6 times daily, was administered. Staphylococcus aureus susceptible to flucloxacinil were isolated from cultures of swabs of the amputation wounds of the fingers, of the stump from the Syme’s amputation, and of the left foot wound. Seven hundred fifty sterile maggots (Polymedics Bioproducts) in 20 porous, polyvinyl alcohol (PVA) bags (“biobags”) were placed on the wounds intraoperatively (figure 2). After 3 days, the patient’s clinical situation had improved substantially, and the high fever had subsided. The wounds showed significant improvement: granulating tissue had begun to grow and the amount of necrotic tissue was reduced. Therapy with maggots in biobags was administered 7 times, and additional surgical debridement was not necessary. After 5 weeks, a superficial soft-tissue defect at the top of the partial amputation of the fifth finger of the right hand and the wound on the left foot were covered with autologous mesh grafts. After 2 months, the patient was discharged from the hospital to a rehabilitation center, and at 5 months all tissue defects had healed. The patient is able to walk with a prosthesis, without the help of crutches, and he is able to use both hands well (figure 3).

Case history 2. A 54-year-old man with insulin-dependent diabetes mellitus and a smoking history of 35 pack-years had undergone an amputation of the first (great) toe of his left foot because of a nonhealing small wound. A surgical wound infection with S. aureus spread to the lower left leg, and amputation of the lower limb was done. Subsequently, the stump became infected and would have required an extended amputation (figure 4). At this point, the patient was transferred to our hospital. At admission, he had a severe infection with...
Figure 1. Patient 1. Necrosis of the hand, a sequela of meningococcal sepsis.

Figure 2. Patient 1. After partial amputation of the second through the fifth fingers, the left hand was covered with 5 “biobags” containing 20–30 maggots each. The porous polyvinyl alcohol membrane of the biobags allows free exchange of secretions and wound debris.

wet gangrene of the stump, which required immediate surgical debridement and partial resection of the soleus and gastrocnemius muscle. The remaining tissue, however, showed poor vascularization. Postoperatively, maggot therapy was initiated; the patient did not receive systemic antibiotic therapy. The local inflammation rapidly decreased, and the condition of the lower extremity and upper leg improved (figure 5). Within 1 week, signs of infection were subsiding, and the wound showed signs of granulation. For 2 weeks, the wound was treated with a combination of maggots and PVA foam (Biogard; Polymedics), after which maggot therapy was stopped and vacuum sealing treatment with PVA foam (Vacuseal/VAC Soft-Foam; KCI) was
administered for another week. Finally, the wound was covered with a mesh graft transplant. The patient was discharged from the hospital after 5 weeks. Four months after discharge, the patient could walk with a prosthesis. After >3 years of follow-up, no signs of infection have occurred (figure 6).

**Discussion.** These 2 patients with severe, secondarily infected necrotic wounds were treated with maggots, and this approach apparently helped remove necrotic tissue and prevented the need for disabling amputations of hands or limbs. For patient 1, an open amputation of both upper extremities below the elbow joint and both lower legs would have been necessary. For patient 2, who had diabetes, severe infection of the stump of the lower leg coincided with wet gangrene, a condition that usually necessitates amputation up to the upper leg. In both cases, maggots were applied to remove remaining necrotic tissue, thus helping to prevent the need for disabling amputations.

In case of severe infections of a limb, natural “biosurgery”
by sterile maggots may prevent the need for amputation and thus preserve the patient’s quality of life [6]. Maggots (larvae of L. sericata) act as necrophages and destroy bacteria [7, 8]. The mechanism for the beneficial effect of maggot therapy is likely their extracorporeal digestive system. Maggots produce enzymes such as trypsin, peptidase, and lipase and release them into the environment. This may help break down debris and necrotic tissue, while leaving healthy tissue unharmed. The resulting semiliquid debris is absorbed and digested by the maggots [9, 10, 11]. In addition, maggots secrete allantoin, ammonia, and calcium carbonate, which produce an alkaline environment [12]. This acts as a barrier against bacterial colonization and stimulates the growth of granulation tissue [4]. Also, the crawling of maggots on the wound is thought to create a mechanical stimulus for growth of granulation tissue [5].

We used 2 methods to apply maggots to the wounds of the 11 patients in our series. For the first 3 patients, sterile maggots were put freely on the wound surface, which was then covered with a loose net dressing (table 1; patients 2, 3, and 6). After 3–4 days, maggots grow to 8–10 mm in length and the wound

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**Figure 5.** Patient 2. Lower left leg stump: 200–700 maggots were applied directly to the wound surface.

**Figure 6.** Patient 2. Lower left leg stump at the 1-year follow-up examination.
becomes painful because of their biting and crawling (figure 5). Usually, large numbers of larvae (e.g., >100) are applied to the wound surface, and administration of regional anesthesia often becomes necessary to reduce pain. Therefore, more recently, larvae have been incorporated within small “biobags,” the size of ordinary tea bags, made of porous PVA membrane. Maggots in biobags are no less active necrophages than are free maggots; they secrete enzymes and absorb wound debris through the permeable bag membrane, but do not cause the painful sensation of biting and crawling larvae directly on the wound (figure 2). After the maggots have cleaned the wound, the biobags containing the maggots are removed, and rapid growth of granulating tissue may then be stimulated by vacuum sealing of the wound with PVA foam and polyurethane film [13] at a suction pressure of 50–60 kPa.

In the 2 cases we describe here, amputation of extremities could be avoided, despite the serious medical problems of severe infection and vascular insufficiency secondary to smoking and diabetes mellitus. The preservation of the extremities was possible, at least in part, because of application of “surgical” maggots. During the last 3 years, we have used maggots as adjunct treatment for 11 patients (table 1). The range of underlying diseases in these patients (open osteomyelitis in 5 patients, gangrene in 2, and soft-tissue infection or Charcot’s joint in 4) matches the indications mentioned in the sparse literature on the subject: for example, osteomyelitis [14], venous ulcers [15, 16], and diabetic foot infection [6]. In one study, 12 patients with venous ulcers were randomized to receive either larval debridement therapy or treatment with a hydrogel dressing; this study showed the cost-effectiveness and efficacy of maggot therapy [16]. Although the methodological limitations of the present open-label, noncomparative cohort study precludes a definite conclusion concerning clinical efficacy, we believe that, for our patients, the local application of maggots, in most cases followed by vacuum sealing with PVA foam, may have helped prevent the need for disabling amputations. Nine of 11 patients recovered fully, and 2 died during follow-up. Deaths were not related to the primary infection for which maggots were applied: 1 patient died because of an accident and the other died months after treatment was finished because of an underlying hematologic disorder. Our experience shows that, even now, there may still be a place for an ancient treatment modality, such as application of “surgical” maggots.

### Table 1. Summary of clinical characteristics of 11 patients treated locally with sterile maggots.

<table>
<thead>
<tr>
<th>Patient</th>
<th>Sex, age in years</th>
<th>Diagnosis</th>
<th>Infected region</th>
<th>Underlying condition(s)</th>
<th>Duration of maggot therapy, days</th>
<th>Dressing or no. of biobags used</th>
<th>Total no. of maggots applied</th>
<th>No. of times maggots changed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>M, 50</td>
<td>Osteomyelitis</td>
<td>Tibia/fibula</td>
<td>Vascular insufficiency</td>
<td>32</td>
<td>88</td>
<td>80</td>
<td>9</td>
</tr>
<tr>
<td>2</td>
<td>M, 60</td>
<td>Osteomyelitis</td>
<td>Knee joint</td>
<td>Vascular insufficiency, DM</td>
<td>12</td>
<td>Net</td>
<td>1000</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>M, 41</td>
<td>Osteomyelitis</td>
<td>Both feet</td>
<td>Crush trauma to both feet</td>
<td>28</td>
<td>Net</td>
<td>2900</td>
<td>7</td>
</tr>
<tr>
<td>4</td>
<td>M, 81</td>
<td>Osteomyelitis</td>
<td>Femur</td>
<td>Trauma, steroid treatment, DM, vascular insufficiency</td>
<td>28</td>
<td>31</td>
<td>550</td>
<td>8</td>
</tr>
<tr>
<td>5</td>
<td>F, 62</td>
<td>Osteomyelitis</td>
<td>Tibia/fibula</td>
<td>Trauma, vascular insufficiency</td>
<td>20</td>
<td>24</td>
<td>360</td>
<td>6</td>
</tr>
<tr>
<td>6</td>
<td>M, 54</td>
<td>Gangrene</td>
<td>Lower leg stump</td>
<td>Vascular insufficiency, DM</td>
<td>11</td>
<td>Net</td>
<td>2000</td>
<td>3</td>
</tr>
<tr>
<td>7</td>
<td>M, 65</td>
<td>Gangrene</td>
<td>Both hands and feet</td>
<td>Meningococcal sepsis</td>
<td>27</td>
<td>78</td>
<td>2100</td>
<td>8</td>
</tr>
<tr>
<td>8</td>
<td>F, 88</td>
<td>Soft-tissue infection</td>
<td>Femur</td>
<td>Trauma</td>
<td>27</td>
<td>28</td>
<td>450</td>
<td>8</td>
</tr>
<tr>
<td>9</td>
<td>M, 46</td>
<td>Soft-tissue infection</td>
<td>Abdomen and perineal region</td>
<td>Fasciitis necroticans</td>
<td>19</td>
<td>88</td>
<td>1200</td>
<td>5</td>
</tr>
<tr>
<td>10</td>
<td>M, 51</td>
<td>Soft-tissue infection</td>
<td>Femur</td>
<td>Trauma, vascular insufficiency</td>
<td>13</td>
<td>7</td>
<td>100</td>
<td>4</td>
</tr>
<tr>
<td>11</td>
<td>M, 63</td>
<td>Ulcus cruris, Charcot’s joint</td>
<td>Lower leg</td>
<td>Chronic ulcers, DM, RA, steroid treatment</td>
<td>34</td>
<td>78</td>
<td>1000</td>
<td>10</td>
</tr>
</tbody>
</table>

**NOTE.** DM, diabetes mellitus; F, female; M, male; RA, rheumatoid arthritis. “Biobags” indicates porous, polyvinyl alcohol bags containing maggots; “net” indicates a loose nylon mesh wound dressing over free maggots.

### References

3. Larrey, Baron DJ. Observations on wounds, and their complications by erysipelas, gangrene and tetanus etc. [in French]. Rivinus EF, trans. Philadelphia: Key, Mielke, & Biddle, 1832-34.

1570 • CID 2002:35 (15 December) • BRIEF REPORT
10. Stoddard SR, Sherman RM, Mason BE, Pelsang DJ. Maggot debride-
ment therapy, an alternative treatment for nonhealing ulcers. J Am
11. Ziffren SE, Herbert HE, May SC, Womack NA. The secretion of col-
Konzept zur Behandlung von Weichteil- und Knochen-Infektionen.
14. Galeano M, Ioli V, Colonna M, Risitano G. Maggot therapy for treat-
ment of osteomyelitis and deep wounds: an old remedy for an actual
15. Sherman RA, Tien Tran JM, Sullivan R. Maggot therapy for venous
effectiveness of larvae therapy in venous ulcers. J Tissue Viability