

Use of larvae in the treatment of the diabetic necrotic foot

Anne Rayman, Glynis Stansfield, Trudi Woollard, Alasdair Mackie, Gerry Rayman

Introduction

The management of gangrenous digital lesions in the ischaemic diabetic foot where vascular intervention is not possible or has been unsuccessful is limited. Local surgical and enzymatic debridement is often considered hazardous and many surgeons choose to leave necrotic toes to autoamputate (Edmonds and Foster, 1994). Unfortunately, autoamputation can be a protracted process, and unpleasant for the patient and relatives; there is also a risk of recurrent infection. This article describes our experience of using the larvae (maggots) of the green bottle fly (*Lucilia sericata*) to excise dry gangrenous toes.

Several recent articles have related the history of larval therapy (Thomas et al, 1996a,b; Jones and Thomas, 1997). Thomas et al (1996a) described the observations of Larrey, military surgeon to Napoleon in 1829, who said:

'These insects accelerated cicatrisation by shortening the work of nature and by producing an elimination of necrotic cells by devouring them without disturbing living tissue.'

Similar potential benefits of maggots were described by Jones, a medical officer in the American Civil War, who reported

'frequently seen neglected wounds... filled with maggots. As far as my experience extends, these worms only destroy dead tissues, and do not injure specifically the well parts' (Chernin, 1986).

The first therapeutic use of maggots is accredited to Zacharias, another confederate medical officer, who claimed that

'maggots in a single day would clean a wound much better than any agents we had at our command ... I'm sure I saved many lives by their use' (Chernin, 1986).

During the First World War, Baer, an orthopaedic surgeon at Johns Hopkins University, observed that the wounds of two soldiers who had been overlooked on the field of battle, though filled with maggots, were granulating well and were free of sepsis. Years later, recalling his wartime

experiences, he successfully treated several cases of intractable osteomyelitis using maggots. His work was published posthumously by his colleagues (Baer, 1931). This led to an increased interest in the use of maggots. The first commercial preparation was produced by Lederle in the 1930s, but the introduction of antibiotics in the 1940s resulted in a rapid decline in their use (Lederle Laboratories Inc, 1932).

Clinical use

Each female *Lucilia sericata* (green bottle fly) will lay up to a thousand eggs, from which larvae of 1–2 mm in length emerge after a few days. The larvae feed by breaking down devitalised tissue through the release of powerful proteolytic enzymes and collagenases to produce a semi-liquid soup, which is reabsorbed and digested (Vistnes et al, 1981). After feeding for 4–5 days the larvae must leave the wound to pupate, otherwise they will die. After a further 7 days they emerge as adult flies.

The sterile larvae used in the UK are obtained from the Surgical Materials Testing Laboratory, Bridgend, Wales. The larvae are dispatched in small flasks containing between 150 and 200 maggots per flask. The aim is to introduce approximately 10–15 larvae per square centimetre into the wound; in practice, however, it can be difficult to count the larvae as they are only a millimetre in length.

ARTICLE POINTS

1 There is limited treatment available for the diabetic necrotic foot.

2 Larval therapy is an effective and safe means of removing necrotic toes.

3 It is safer and quicker than leaving the toes to autoamputate.

4 It has the benefit of abolishing the odour associated with infection and necrosis.

5 It is readily accepted by most patients.

KEY WORDS

- Larvae
- Necrotic toes
- Diabetes

Anne Rayman is Diabetes Research Nurse, Glynis Stansfield is Tissue Viability Sister, and Trudi Woollard is Senior Diabetes Chiropodist at The Ipswich Hospital; Alasdair Mackie is Consultant Physician at the Northern General Hospital, Sheffield; and Gerry Rayman is Consultant Physician at The Ipswich Hospital

PAGE POINTS

1 If the tissue is too dry the larvae are unable to feed, and subsequently die.

2 Moistening the wound with Intrasite Gel for several days beforehand is effective in creating a suitable feeding bed.

3 The larvae produce a powerful mixture of proteolytic enzymes (Vistnes et al, 1981), which break down the necrotic tissue.

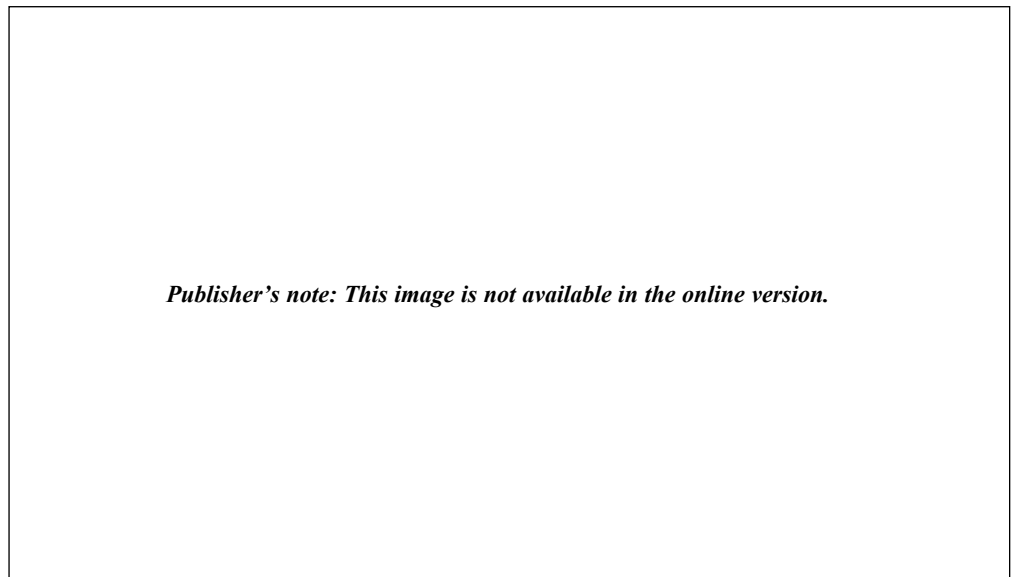


Figure 1. Application of Granuflex to protect the surrounding skin from larval secretion.

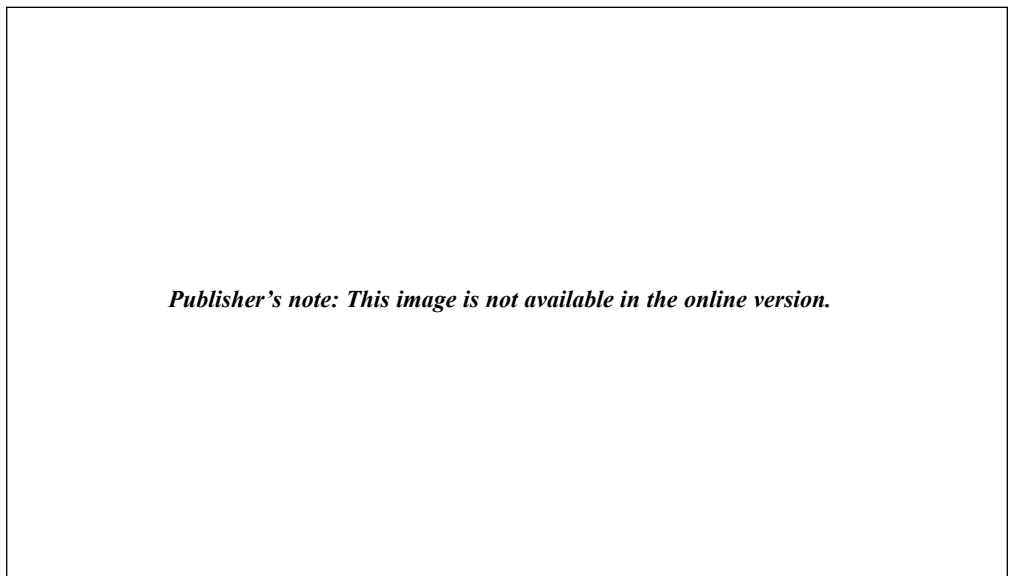


Figure 2. Fine gauze netting taped to the Granuflex by waterproof tape to cover the wound and retain the larvae.

Many of the wounds that we have treated have dry gangrenous areas. We have noticed that if the tissue is too dry the larvae are unable to feed, and subsequently die. We have found that moistening the wound with Intrasite Gel for several days beforehand is effective in creating a suitable feeding bed. The Intrasite Gel must be thoroughly removed before application of the larvae.

The larvae produce a powerful mixture of proteolytic enzymes (Vistnes et al, 1981), which break down the necrotic tissue. The healthy tissue surrounding the wound is protected by a barrier of hydrocolloid material affixed to the edge of the wound (Figure 1). This also acts as

an anchor for the sterile net that is used to cover the wound and retain the larvae. The net is taped to the hydrocolloid with plastic adhesive tape. For this we have used Slek (Figure 2). The net is then covered with a large pad and gauze bandage, which leaves the wound well covered but allows the larvae to breathe.

After 2–3 days the larvae have grown to 6–10 mm in length, and are removed by irrigating the area with warm saline dispensed from a 20-ml syringe. This is a relatively easy procedure to perform, although catching the fast-moving larvae can be a challenge! The larvae are disposed of in yellow bags for incineration.

The following case studies in diabetic patients illustrate the successful use of larvae in amputating gangrenous toes that may otherwise have taken many months to autoamputate.

Case study 1

The first patient was a 52-year-old man with insulin-treated type 2 diabetes, initially diagnosed in 1972. He had developed a number of severe complications including laser-treated retinopathy (1985) and nephropathy (1991) with chronic renal impairment.

His foot problems started in 1985 when he developed neuro-ischaemic ulcers on the toes of his right foot, for which vascular reconstruction was not possible. The first and second toes took 11 months to autoamputate. In 1994, following further ischaemic necrosis, a right Syme's

amputation had to be performed.

The problems with his left foot began in 1996 when he presented with gangrenous third, fourth and fifth toes. Angiography showed no patent vessels below the knee. It was decided to leave the toes to autoamputate, but over the following 8 months he had three episodes of severe infection in the adjacent tissue, and the foot permanently exuded an offensive smell which distressed the patient and his carers (Figures 1 and 2). It appeared to us that larval therapy had a possible role in the treatment of this patient as it could potentially excise the malodorous necrotic tissue.

Five treatments were carried out over a 6-week period. On each occasion the larvae were left on the wound for 3 days and then removed (Figure 3), after which the patient had a weekend break. By 6 weeks after the last treatment the wound had closed completely (Figure 4).

This was a great success; the staff and patient were all delighted with the result, which allowed the patient to again lead an active role in his family life. Unfortunately, a year later this patient developed further problems, including worsening renal failure and progressive heart failure, and required bilateral lower limb amputations for infected pressure ulcers. He died of intractable heart failure.

Case study 2

The second patient was a 76-year-old woman with insulin-treated type 2 diabetes diagnosed in 1970. She had several complications, including angina, sight loss from diabetic retinopathy and renal impairment. In 1994 she had a left below-knee amputation following a failed bypass graft. Her general health was very poor and she remained hospitalised for 8 months because of a large sacral sore and heart failure. Shortly after discharge she developed a necrotic right third toe which took 8 months to autoamputate.

In 1996 she developed ischaemic necrosis of her right first and second toes, but was unfit for surgery. Over the next few months she suffered a myocardial infarct and developed worsening heart failure and renal failure. Over the subsequent 3 months she suffered recurrent infections of the ischaemic toes — on one occasion

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Figure 3. After 2–3 days the larvae are removed by irrigating with a jet of saline.

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Figure 4. Wound almost completely closed after 5 weeks.

the infection was life-threatening — and the wound was persistently positive for methicillin-resistant *Staphylococcus aureus* (MRSA). The smell distressed the patient and was beginning to alienate her husband and family. After two treatments with larvae, the toes were successfully amputated with complete disappearance of the odour, which allowed the relatives to visit once again in some comfort. The area was beginning to heal, but sadly the patient died from congestive cardiac failure 3 months later, before her wound had completely closed.

Case study 3

This patient was a 78-year-old woman with type I diabetes diagnosed in 1964 and peripheral vascular disease. She had undergone a left below-knee amputation in 1992. In 1995 she had an angioplasty for ischaemia with small areas of necrosis of the

right first and second toes. Eight months later she required a further angioplasty and was left with gangrenous first and second toes, but because her circulation was poor it was decided to leave these to autoamputate. During these months, like the previous patients, she suffered recurrent infections and hospitalisation (Figure 5).

She agreed to larval therapy and had four treatments over an 8-week period. The therapy was discontinued for 4 weeks because of an episode of cellulitis. Three months after the initial treatment, all the necrotic tissue had been removed and the lesion had completely healed (Figure 6).

Other cases

Two other patients with necrotic toes have had these successfully amputated, in each case after a single application of maggots. We have also used maggots as a last resort to debride and reduce the odour in a patient with deep foot and lower limb ischaemic ulcers who steadfastly refused reconstructive surgery. This patient eventually agreed to surgery, but at this stage a below-knee amputation was the only option.

Discussion

Larval therapy has re-emerged as a safe and effective method of debriding (Thomas et al, 1996a) and sterilising a variety of surgical wounds, particularly chronic wounds from which multiple organisms including MRSA can be cultured (Stoddard et al, 1995).

It is believed that the larvae combat infection by ingestion and digestion of microorganisms and the production of agents with antibacterial activity (Pavillard and Wright, 1957; Stoddard et al, 1995). In diabetic foot ulcers, recurrent infection can often be a problem (Foster, 1995); many patients require repeated courses of antibiotics, sometimes for extended periods. Antibiotic therapy, however, is often associated with nausea and antibiotic-induced diarrhoea, both of which can further weaken these already compromised patients. In such cases, larval therapy may have an important role in eradicating infection, particularly MRSA, from diabetic ulcers (Thomas et al, 1996b; Jones and

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Figure 5. Chronic necrotic tissue that has developed recurrent infections.

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Figure 6. Complete removal of necrotic tissue and healing after larval therapy.

Thomas, 1997).

In the cases described, larval therapy was successfully used not only to debride and sterilise but also to amputate necrotic digits. In each case the digits were completely excised, leaving clean and healthy-looking tissue from which effective granulation occurred.

Amputation by larvae is thought to be achieved through enzymatic digestion of necrotic tissue at the demarcation line between living and dead tissue. It could be argued that similar results may have been achieved by surgical amputation, but the common policy among surgeons of leaving digits to autoamputate suggests otherwise. Surgical debridement inevitably damages some of the adjacent tissue and blood supply. The localised bleeding observed after surgical debridement is evidence of this. Whether larvae damage healthy tissue is uncertain, but most clinical observations suggest that this is not the case (Chernin, 1986; Thomas et al, 1996a). In our experience, there is no localised bleeding with larval therapy. Furthermore, in the absence of small vessel damage, granulation is likely to be quicker and more effective.

Unfortunately, two of the above patients died some months after larval therapy, from associated diabetic complications. Both of these patients reflect the rather dismal prognosis for many of our foot ulcer patients who have severe micro- and macrovascular complications (Connor, 1987). In each case, however, absence of the unpleasant odour (Price, 1996) and removal of the sight of the necrotic tissue were very much appreciated by the patients and their relatives.

Once the larval therapy had been fully explained to the patients and their relatives, and the apprehension surrounding the first treatment had been overcome, subsequent treatments were readily accepted. Surprisingly, it was some of the staff who found acceptance more difficult.

One of our concerns at present is the use of hydrocolloid to protect the adjacent skin. In most of the patients treated, non-necrotic skin under the hydrocolloid appeared to become overhydrated and fragile. This change is in keeping with observations by others that hydrocolloids

can macerate healthy skin in the diabetic foot (Foster et al, 1997). We are currently looking for an alternative dressing to provide the barrier between the treated and untreated areas.

The cost of each treatment is about £50. However, in the patients reported here, where the home circumstances were difficult or the patient too ill, there was the added cost of inpatient care. We have since treated patients successfully on an outpatient basis, utilising the good liaison we have with the district nurses.

Conclusion

Larval therapy is an effective and safe means of removing necrotic toes when surgery is considered too risky. It is safer and quicker than leaving the toes to autoamputate. It is readily accepted by the majority of patients and has the benefit of abolishing the offensive odour associated with infection and necrosis. ■

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