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Review Article

Maggot Therapy and its Implications in Veterinary Medicine: An Overview

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Abstract

Alternative therapies to conventional wound management are available now-a-days to facilitate faster wound healing without any complications. Among various alternative therapies, it has been well established that maggot therapy can be used successfully to treat chronic long-standing infected wounds which previously failed to respond to conventional treatment. Maggot therapy employs the use of freshly emerged, sterile larvae of the common greenbottle fly, *Phaenicia (Lucilia) sericata*, and is a form of artificially induced myiasis in a controlled clinical situation. Maggot therapy, however, is used relatively little in veterinary medicine. Nevertheless, concern over antibiotic resistance and the increase in demand for organic husbandry and residue-free meat and milk, suggest that it is an option which merits further consideration. In this review article, authors' discuss the role of maggots and their preparation for veterinary medical use.

Keywords: Maggot therapy; debridement; Horse; Navicular bursitis

Introduction

Maggot therapy is the application of sterile first instar larvae (maggots) fly larvae to debride the chronic wound bed of necrotic tissue, reduce the bacterial contamination and enhance the formation of healthy granulation tissue. In human medicine the use of maggot therapy has been practiced sporadically from centuries. Evidence suggests that ancient Mayans, as a means of attracting maggot strikes, soaked dressings in cattle blood and applied them to their own wounds (Sherman and Pechter, 1988). In 1559, Pare noted the beneficial effects of maggots in combating trauma in the battlefield (Trudgian, 2002). The first documented application of maggots was by John Zacharias, a surgeon in the American civil war as follows: "During my service in the hospital at Danville, Virginia, I first used maggots to remove the decayed tissue in hospital gangrene and with eminent satisfaction. In a single day, they would clean a wound much better than any agents we had at our command. I used them afterwards at various places. I am sure I saved many lives by their use, escaped septicaemia, and had rapid recoveries" (Chernin, 1986).

Prior to the development of antibiotics, maggot therapy was used particularly for the treatment of various types of necrotic wounds including chronic leg ulcers, osteomyelitis and greatly improved the prognosis for patients with such conditions (Trudgian, 2002). William S. Baer, Professor of Orthopaedic Surgery at the John Hopkins School of Medicine in Maryland, USA, is believed to be the founder of modern maggot therapy. Baer was impressed by the remarkable healing of compound fractures of the femur and large abdominal wounds in a soldier left unattended for several days without food or water. Although his wounds were covered with thousands of maggots, the patient was afebrile, no bare bone was seen, and healthy granulation tissue surrounded the traumatized tissues. Similarly open lesions in all the 21 patients at Johns

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Hopkins University in 1929 with chronic intractable osteomyelitis healed completely without any complications owing to application of maggots by Baer (1931). Despite obvious success of maggot therapy, by the mid-1940s it had practically disappeared from use due to introduction and widespread use of various antibiotics. Innovative surgeons and practitioners are now taking a second look at maggots, especially with regard to the gear up in antibiotic resistance. In addition to the idea of antibiotic resistance, cases that might benefit from maggot therapy are those where the blood supply to a region is compromised or in the process of regenerating; maggots can consume infected tissue since there is no blood to bring antibiotics to the area (Honnas *et al*., 1995).

With the increasing incidence of bacterial resistance to antibiotics, the great expense and protracted development of new antibiotics and the high cost of prolonged treatment, interest in the use of maggot-therapy in human medicine is growing at a faster rate. Maggot therapy, however, is used relatively little in veterinary medicine. Nevertheless, concern over antibiotic resistance and the increase in demand for organic husbandry and residue-free meat and milk, suggest that it is an option which merits further consideration.

Types of fly larvae used in maggot therapy

The majority of the fly larvae associated with myiasis are not suitable for therapy. Species of the obligate agents of myiasis, such as the flesh fly Wohlfahrtia magnifica (Diptera: Sarcophagidae) and the screw worm species, Chrysomya bezziana or Cochliomyia hominivorax (Diptera: Calliphoridae) are not used since these flies feed aggressively on underlying living tissue (Jones and Wall, 2008). The larvae of facultative agents of myasis, particularly Lucilia serrata (Diptera: Calliphoridae) – the familiar greenbottle blowfly responsible for blowfly strike of sheep, feed relatively superficially and therefore are the most suitable and commonly used species (Prete, 1997).

Mechanism of action

The beneficial effects of maggot therapy on infected wound are mainly due to debridement, disinfection and enhanced healing. Debridement is the removal of cellular debris and non-viable necrotic tissue from the wound bed. This is a first, essential step before healing can commence. How exactly maggots remove devitalized, necrotic tissue from the wound is currently actively being investigated. Research into the debridement mechanisms underlying maggot therapy has revealed that maggots secrete a rich soup of digestive enzymes while feeding, including carboxypeptidases A and B (Vistnes and Ksander, 1981), leucine aminopeptidase, collagenase (Ziffren *et al*., 1953) and serine proteases (trypsin-like and chymotrypsin-like enzymes) (Casu *et al*., 1994). Recently four proteolytic enzymes, secreted by P. sericata larvae, comprising two serine proteases, a metalloprotease and an aspartyl protease have been detected with activity across a wide pH range. A chymotrypsin-like serine protease exhibited excellent degradation of extracellular matrix (ECM) components laminin, fibronectin, and collagen types I and III (Chambers et al., 2003), and may therefore play a significant role in the digestion of wound matrix and effective debridement. The mechanical action of numerous wriggling maggots in a necrotic debris-filled wound has also been suggested in aiding wound debridement. Maggots possess a pair of mandibles (hooks) which assist in locomotion and attachment to the tissues. This probing and maceration of wound tissue with maggot mouth hooks may enhance debridement, but these hooks are used during feeding to disrupt membranes and thus facilitate the penetration of proteolytic enzymes (Thomas *et al*., 1996). Maggots are photophobic and will naturally move into the deep crevices that may be beyond the reach of a surgeon's scalpel (Nigam *et al*., 2006a). Removal of necrotic tissue abolishes many of the associated bacteria and also reduces wound odour. The removal of necrotic tissue, which acts as a microbial substrate, may also reduce the risk of infection (Schultz *et al*., 2003). This therapy is suitable for most types of wounds that contain necrotic or sloughed tissue irrespective of etiology. Further several mechanisms have been described which enhance the healing of infected wounds which include, actual ingestion of the tissue by the larvae, physical presence of the larvae in the infected tissue increasing the exudate from the host which washes out the bacteria, secretions from the larvae altering the wound pH, digestion and subsequent destruction of bacteria in the larval alimentary tract due to antibacterial substances and the crawling action of the larvae stimulating granulation tissue (Weil *et al*., 1933, Mumcuoglu *et al*., 1998, Bunkis *et al*., 1985).

Application of Maggots

Before application of maggots, it should be borne in mind that maggot therapy is only useful to chronic wound which contain necrotic and sloughed tissues (Hobson, 1931). The different types of wounds suitable for application of maggots include infected wounds, wet necrotic / sloughy wounds, leg ulcers, pressure sores, surgical wounds, malignant wounds, diabetic foot ulcers, amputation wounds and indolent wounds (Schultz *et al*., 2003). Wounds not suitable for maggot therapy include, dry necrotic wounds, fistulae, wounds that connect with abdominal cavity or the other organs, wounds that bleed easily and the wounds close to major blood vessels (Mumcuoglu *et al*., 1998).

Medical maggot therapy in the United States is regulated by the Food and Drug Administration; maggots are purchased by prescription through a licensed laboratory (eg, Monarch Labs, monarchlabs.com). At the laboratory, fly eggs are washed with dilute disinfectant, packaged in sterile containers and allowed to hatch at room temperature. The hatched instar-1 larvae (larvae in the first developmental stage) are translucent white and approximately 2 mm long. Over 4 to 5 days they undergo 2 additional molts, reaching 10 to 14 mm long. Maggots are shipped overnight in a temperature-controlled package. Larvae are used within 24 hours of arrival; however, if necessary, they can be refrigerated for up to 60 hours.

Before placing the maggots, the wound is filled with sterile water-soluble jelly and a wide area around the wound is clipped and vacuumed. The wound bed is then lavaged with 0.9% saline to flush any lubricant or residual topical wound agents. This is especially important if products containing propylene glycol have been used, since these can have a negative effect on maggot viability. The surrounding skin is then cleaned with antiseptic soap, and the area is dried and swabbed with isopropyl alcohol (not to be placed directly on the wound) to remove all dirt and oils. Then a hydrocolloid sheet of the appropriate size is taken and a hole is cut in it according to size and shape of the wound and placed securely onto the surrounding skin. This protects the peri-wound skin and forms a layer upon which to attach the nylon net. Now slowly the saline containing the maggots is poured onto a piece of specially designed net which is inverted over the wound and taped securely to the hydrocolloid sheet using a waterproof adhesive tape such a sleek. The maggots will not fall off the net when it is inverted, as they will be held in place by surface tension. The resultant assembly forms an enclosure that prevents the maggots from escaping onto the surrounding skin. The central part of the net must remain unoccluded in order to permit free drainage of exudate and allow the maggots to obtain an adequate supply of oxygen. After 24 hours of application, maggots are watered by removing the outer dressing (leaving the net and maggots intact) and fresh gauze moistened, but not saturated, with saline is reapplied over the net (Thomas *et al*., 1996).

The maggots are usually left on a wound for 72 hours, because under ideal conditions they will be fully grown by this time. Sometimes, however, if their growth rate is reduced, it may be appropriate to wait for an additional day. The net retention dressing is removed with or without the hydrocolloid frame and maggots are detached with a gloved hand or a pair of forceps. The wound can be gently irrigated with sterile water or saline to remove any remaining or missed maggots. If any maggots are left in the wound, these can be retrieved at the next dressing change. When all the maggots have been removed, the wound should be reassessed to see if further maggot therapy is required or whether a change to this therapy is indicated (Jones and Thomas, 2000).

Maggot therapy in Veterinary medicine

The use of maggots to clean dead tissue from animal wounds is part of folk medicine in many parts of the world. It is particularly helpful with chronic osteomyelitis, chronic ulcers, and other pus-producing infections that are frequently caused by chafing due to work equipment in animals used for draught purpose. Maggot therapy for horses in the United States was re-introduced after a study published in 2003 by veterinarian Dr. Scott Morrison. In horses, maggot debridement therapy is described as an alternative approach to the management of septic navicular bursitis, hoof infections and necrosis in cases of complicated laminitis (Morrison, 2005), osteomyelitis and other hoof diseases (Jurga and Morrison, 2004). This therapy has also been used in supraspinous bursitis, a pathology rarely encountered in equids in the developed world (Doumbia, 2006). When treating this type of wound with maggots the practitioner creates or uses existing openings at either ends of the necrotic cavities to ensure free drainage of exudate and afford the maggots an adequate supply of oxygen. Zinc paste is placed along the margins of these openings, to protect normal tissue, and they are left open. No occlusive or film dressings should be applied overtop, as these may cause the maggots to suffocate. The nets with maggots are changed every 2 to 3 days until complete wound debridement and pink granulation tissue is observed without evidence of infection.

Maggot therapy has been found to decrease the healing time in post-surgical coffin bone debridements, useful in treating chronic reoccurring non-healing foot ulcers, canker, quittor (necrosis of collateral cartilage), navicular bursa sepsis, chronic osteomyelitis/septic arthritis, chronic soft tissue abscess and osteomyelitis secondary to digital instability such as chronic laminitis and reverse rotation secondary to ruptured deep digital flexor tendon (Honnas *et al*., 1992). The other conditions in horses which can be successfully treated by maggot therapy include, chronic digital interphalangeal joint sepsis, acute caudal coffin bone rotation and non-healing foot ulcers (Wrights *et al*., 1999, Richardson *et al*., 1986).

Severe, localised, suppurative panniculitis secondary to a skin wounds in donkeys has been successfully treated by application of sterile larvae (maggots). The lesion did not respond to conventional medical and surgical treatment and continued to progress (Bell and Thomas, 2001). Maggot therapy is also being used in dogs, cats and rabbits to ensure proper debridement and control infection, especially if the wound fails to respond to conventional medical and/or surgical therapy (Sherman *et al*., 2007).

Kocisova et al (2006) used maggot therapy in sheep with acute and chronic interdigital skin inflammation. Before using maggot therapy, they were unsuccessfully treated by a footbath containing 10% copper sulphate and topical application of oxytetracycline solution in alcohol. During the therapy larval population used was that of 8-12 per square centimetre of wound and all affected tissues were trimmed away before the application. The effect of a single application for 3-6 days was evaluated. Debridement was rapid and selective and treatment was well tolerated by animals. It was observed that maggots of L. sericata were capable of cleaning the wounds after single application. Veterinarians at Oklahoma State University Veterinary Hospital successfully used maggots to clear away dead flesh from a wound of a 16 month old filly horse that had been bitten by a rattlesnake. The 16-month-old filly was bitten on the head by a rattlesnake, causing its neck to swell to five times its normal size (http://www.thehorse.com/ViewArticle.aspx?ID=8113).

From these observations in veterinary medicine and different evidences in human medicine (Nigam *et al.*, 2006b), maggot therapy can be recommended for wound debridement, disinfection, enhanced healing and a potent antibacterial action.

Maggot therapy is now well established in modern wound care, with larvae provided by dedicated fly culture laboratories in North America, Europe and Israel (Ryan, 1997). The expectation is that there will be a steady increase in demand for this therapy, particularly as its efficacy and cost effectiveness become more widely recognized. There remains, however, understandable caution and scepticism among clinicians, which can only be overcome by the positive findings of prospective clinical trials, which demand multi-centre collaboration, funding and time. There is an overwhelming need for improved wound care in countries which are under-provided for medical veterinary facilities, mostly in the tropics; the hope is that once the advantages of maggot therapy is fully perceived in the developed world, low-cost local fly culture laboratories will be established in regional centres in the tropics.

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